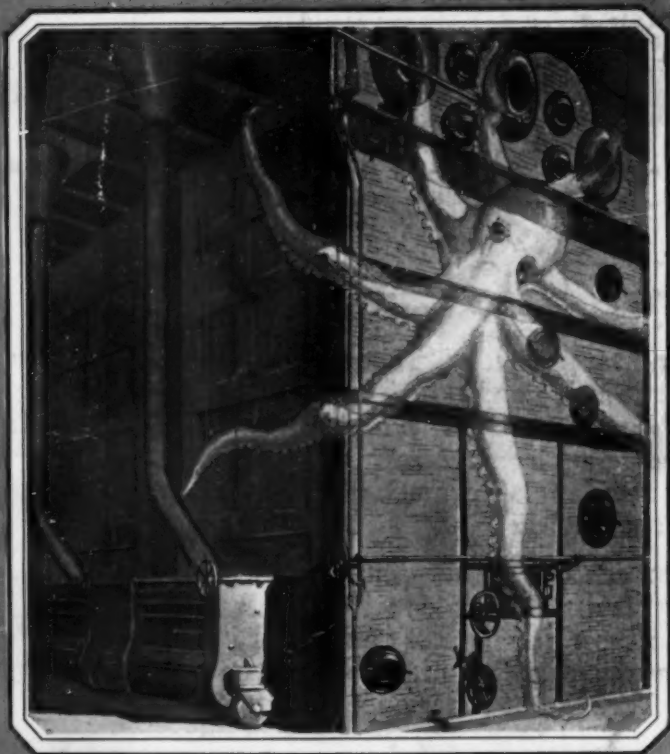


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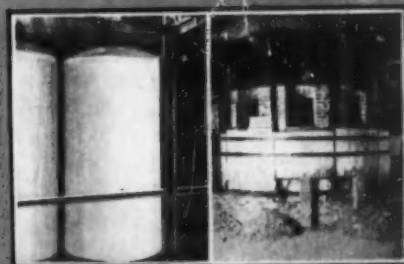


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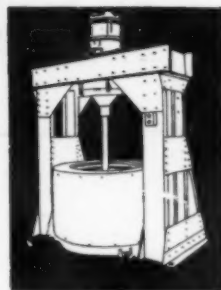
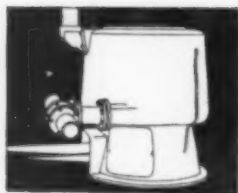
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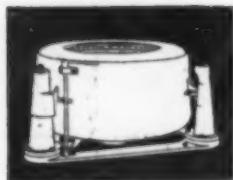
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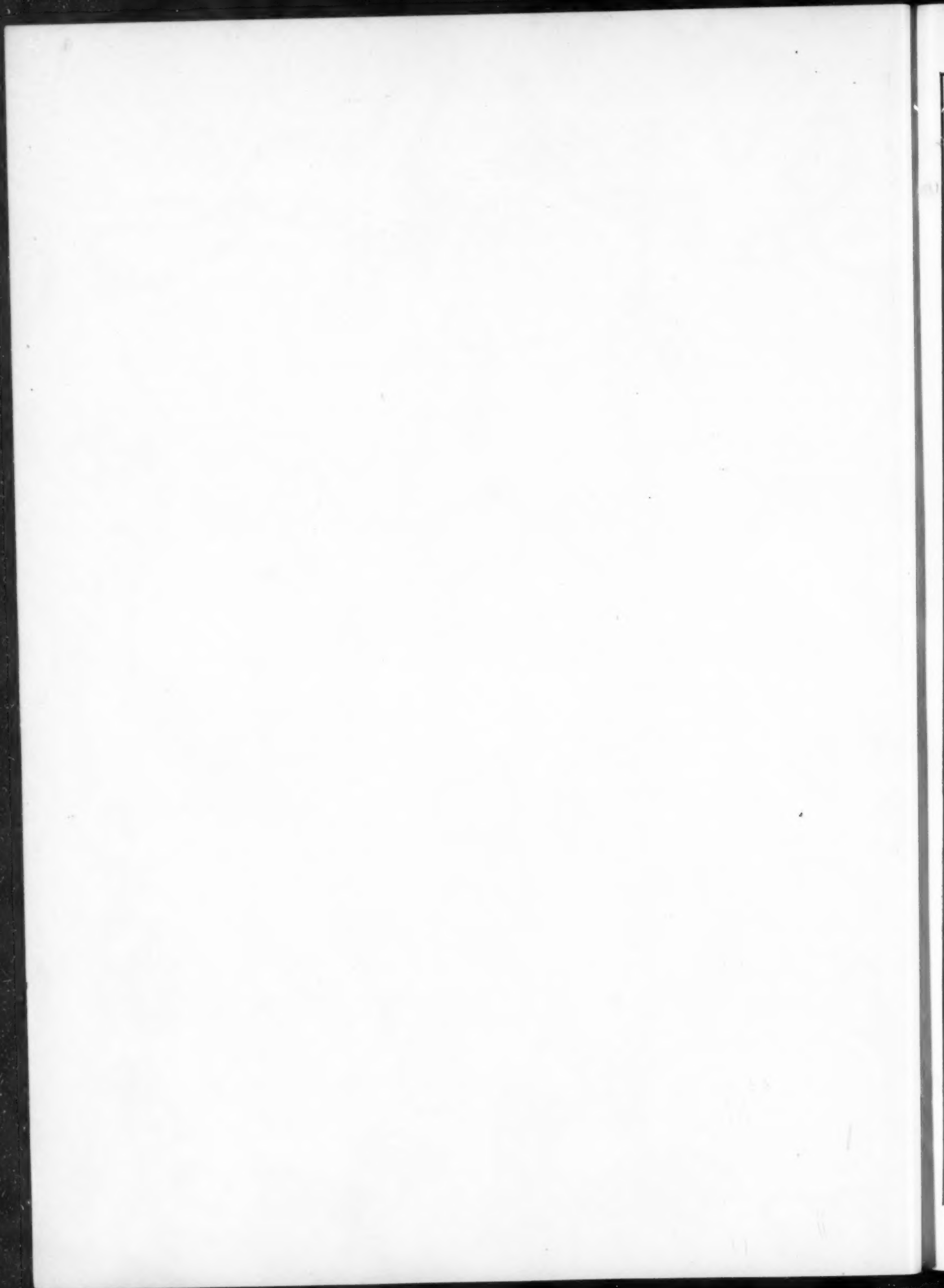
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Chemical & Metallurgical Engineering is the successor to Metallurgical & Chemical Engineering, which, in turn, was a consolidation of Electrochemical & Metallurgical Industry and Iron & Steel Magazine. The magazine was originally founded as Electrochemical Industry.

Fifth Annual Review Number

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McGRAW-HILL PUBLISHING COMPANY, INC., Tenth Avenue at 36th Street, NEW YORK, N. Y.

New York District Office, 285 Madison Avenue

Cable Address: "Machinist, N. Y."

Publishers of

Engineering News-Record American Machinist

Power Chemical and Metallurgical Engineering

Coal Age Construction Methods

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Bus Transportation Electrical World

Electric Railway Journal Radio Retalling

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American Machinist—European Edition

(Published in London)

Number of Copies Printed This Issue, 13,100

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Copyright, 1928, by McGraw-Hill Publishing Company, Inc.

Published monthly. Entered as second-class matter July 13, 1918, at the Post Office at New York, N. Y., under the act of March 3, 1879. Printed in U. S. A.

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LACQUER SOLVENTS

CELLOSOLVE

(Ethylene Glycol mono ethyl ether)

Boiling Point	134.8°C	Acidity	None
Boiling Range	Initial 128°C	Specific Gravity	0.927—0.933
	Dry Point 137°C	Weight per gallon	7.8
Dilution Ratio	6.25 volumes of Toluene (10% cotton solution)		

Cellosolve is the most powerful nitrocellulose solvent commercially available. Its lack of odor makes it particularly valuable in the manufacture of brushing lacquers, architectural lacquers and lacquers for natural or artificial leathers.

CELLOSOLVE ACETATE

(Ethylene Glycol mono ethyl ether acetate)

Boiling Point	154°C	Acidity	Not more than 0.01% (as acetic)
Boiling Range	Initial 140°C	Specific Gravity	0.973—0.982
	Dry Point 165°C	Weight per gallon	8.1
Dilution Ratio	2.6 volumes of Toluene (10% cotton solution)		

Cellosolve acetate is particularly valuable as a retarder and blush resister. It is being widely used in thinners for automobile base lacquers and in the manufacture of "mist coats."

BUTYL CELLOSOLVE

(Ethylene Glycol mono butyl ether)

Boiling Point	170.6°C	Acidity	None
Boiling Range	Initial 163°C	Specific Gravity	0.900—0.905
	Dry Point 174°C	Weight per gallon	7.6
Dilution Ratio	4.00 volumes of Toluene (10% cotton solution)		

Until now there has never been a good nitrocellulose solvent having a boiling range between the usual "high boilers" and the plasticizers. Butyl Cellosolve fills this gap. It is also an excellent gum and resin solvent. The incorporation of small quantities in lacquers insures gradual and even setting of the film with high gloss and absence of orange peel.

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CHEMICAL & METALLURGICAL ENGINEERING

H. C. Parmelee
Editor

Volume 35

New York, January, 1928

Number 1

INTER-DEPENDENCE *Through* CHEMICAL ENGINEERING

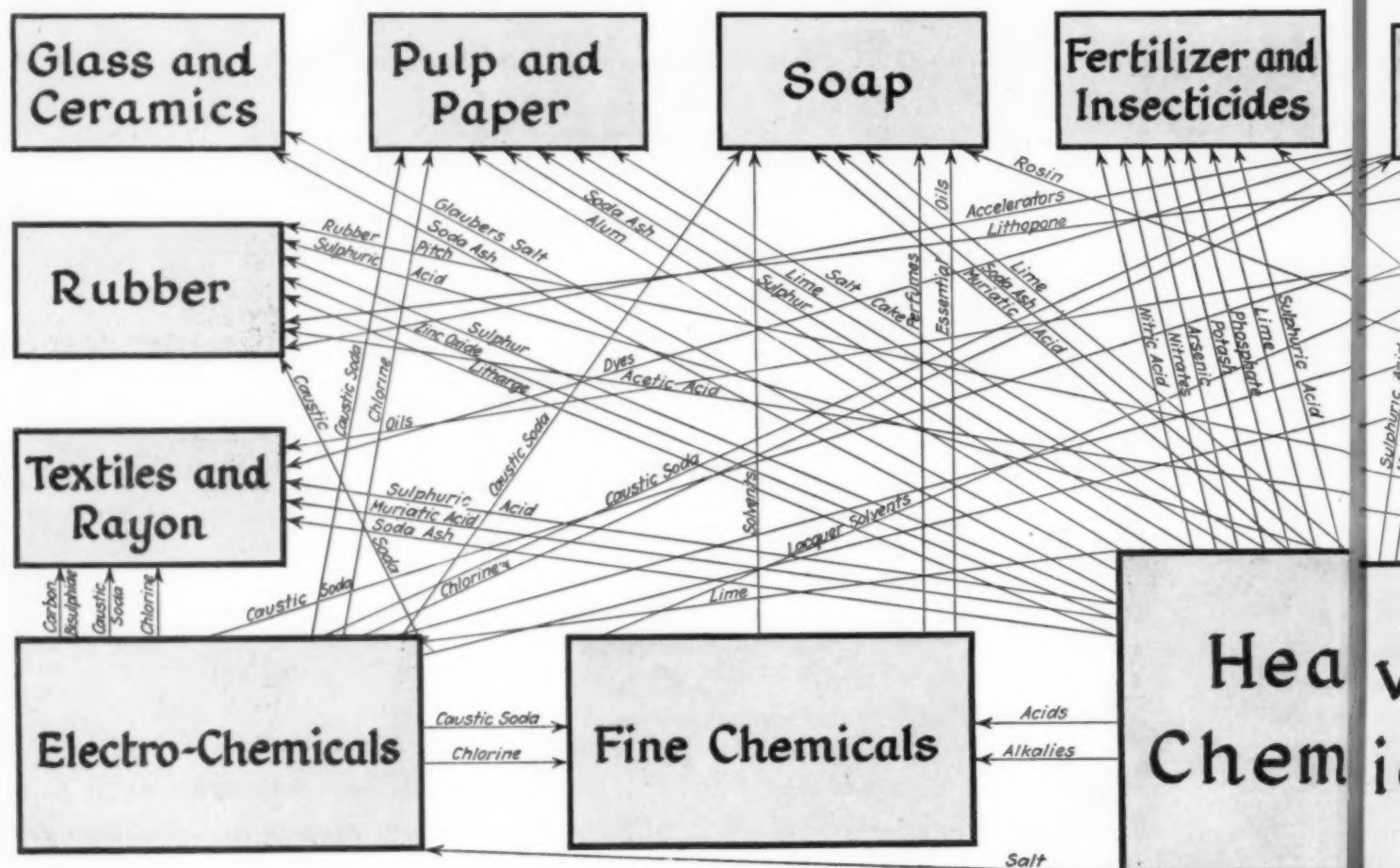
TO Lord Kelvin is attributed the declaration that: "When you can measure what you are speaking about and express it in numbers, you know something about it, and when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind. It may be the beginning of knowledge, but you have scarcely in your thought advanced to the stage of a science."

Nothing could more adequately express the present temper of American industry in its effort to obtain statistical knowledge. Nor could *Chem. & Met.* cite more eloquent reason for this fifth annual contribution to statistical knowledge of the chemical industry. Year by year we are making it increasingly possible for the industry to measure its transactions quantitatively and thus advance in economic as well as technologic thought to the stage of a science.

The year 1928 opens with world-wide interest in the chemical industry, and a clearer understanding of the industrial importance of chemical engineering. Certain industries are gaining a sense of solidarity through their interest in a common technology. In Europe they are even combining in national and international cartels. But regardless of their business affiliations, all these industries typify in their ramifications an editorial theme of this issue—the inter-dependence of the chemical engineering industries.

Can this inter-dependence be accurately measured and expressed? What, for example, is the relationship between the making of explosives and modern lacquers; between coal distillation and fertilizer manufacture; between the production of paper and sugar? And finally what is the incidence of the chemical industry *per se* on all these industries? The answer is indicated on succeeding pages.

CHEMICALS UNDERLIE INDUSTRIES



Inter-Industry Movement of Some of the Chemicals Used in the Chemical Engineering Industries

CHEMICALS have aptly been called raw materials of raw materials. They are key units in the production processes of many industries although their identity may often be entirely lost in the finished products. They serve to weld together as an indivisible whole the great group of chemical consuming industries.

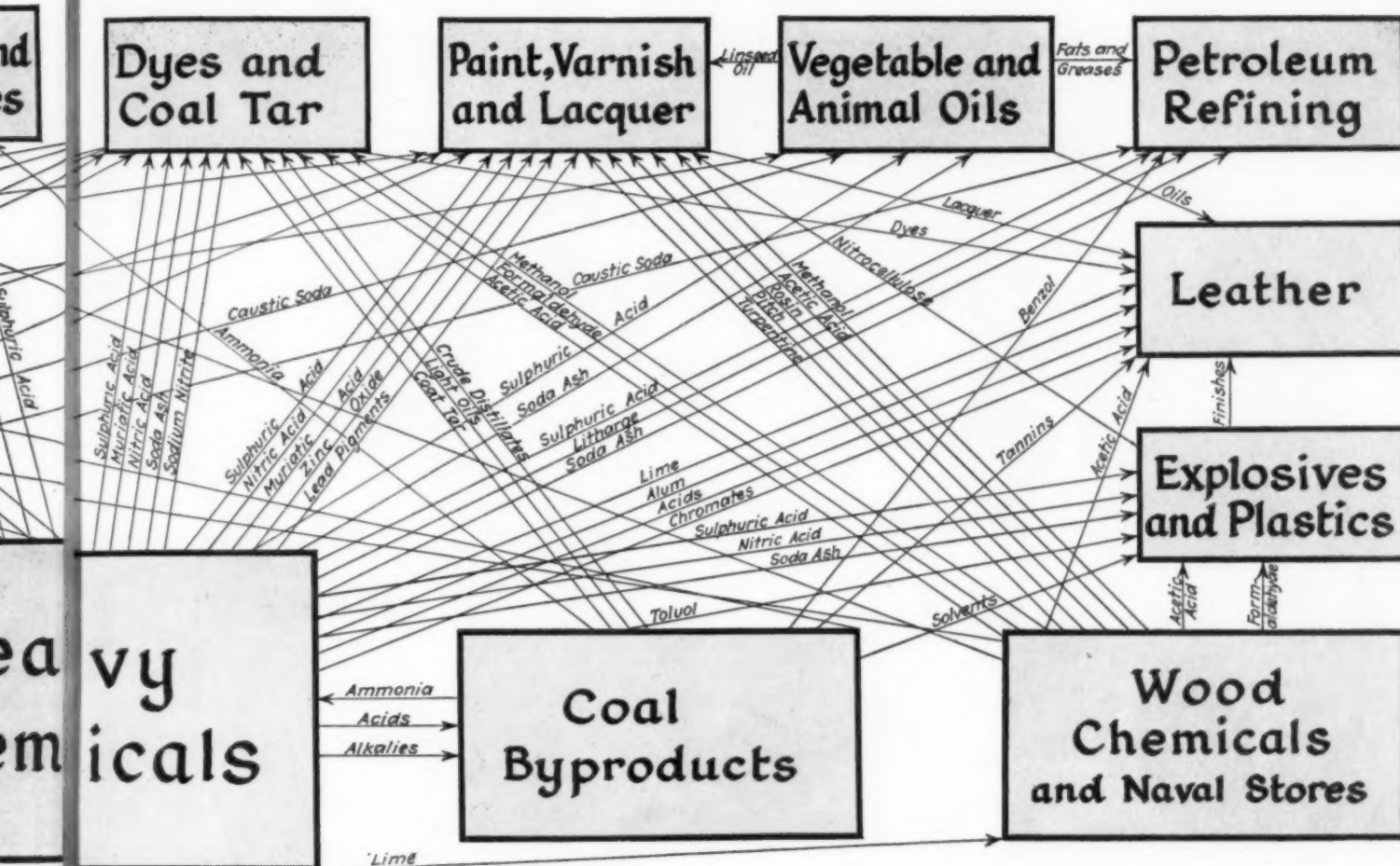
THE complicated network involved in the industrial distribution of chemicals is shown in a fragmentary way by the chart at the top of these pages. More specific data are to be found in the accompanying table in which the most recent Census figures form the basis for estimating the consumption of chemicals in the principal consuming industries. From the standpoint of raw materials, the chemical engineering group is, to a remarkable degree, self contained. The finished product of one chemical engineering industry is very often its neighbor's raw material. The byproduct coke producer buys sulphuric acid (perhaps from a fertilizer plant) in order to make the ammonium sulphate which is sold to the fertilizer manufacturer. The ammonium sulphate, in turn, becomes one of several chemical raw materials that enter into com-

A QUANTITATIVE market survey of the heavy chemical requirements of the chemical engineering group of industries was published in the September (1927) number of *Chemical & Metallurgical Engineering*.

ESTIMATED CONSUMPTION OF CHEMICALS

Industries	Value of Output (Census of 1925)	Cost of Raw Materials Consumed	Estimated Cost of Chemicals Consumed
1. Textiles.....	\$9,122,858,000	\$5,348,050,000	\$133,700,000
2. Heavy and Fine Chemicals.....	547,003,000	271,646,000	96,000,000
3. Paint and Varnish.....	470,736,264	293,943,040	80,000,000
4. Fertilizers.....	206,773,000	137,808,000	76,000,000
5. Drugs and Pharmaceuticals.....	472,494,323	167,786,065	60,000,000
6. Glass.....	295,959,424	113,652,436	44,000,000
7. Leather Tanning.....	462,014,000	306,634,000	40,000,000
8. Rubber.....	1,255,414,112	718,840,524	36,000,000
9. Soap.....	278,273,107	184,873,537	27,500,000
10. Explosives.....	69,668,837	37,877,418	26,000,000
11. Paper and Pulp.....	425,008,293	255,535,840	25,500,000
12. Petroleum Refining.....	2,373,178,000	1,886,603,000	22,000,000
13. Dyes and Coal-tar Chemicals.....	112,201,348	50,727,633	16,500,000
14. Non-ferrous Metals.....	1,067,124,899	912,063,567	15,000,000
15. Rayon.....	88,061,000	18,478,000	12,500,000
16. Iron and Steel.....	3,711,354,460	2,429,378,098	11,500,000
17. Baking Powder and Yeast.....	74,593,000	23,376,000	11,000,000

INDUSTRIAL INTER-DEPENDENCE



Some of the Principal Chemical Raw Materials Used in the Chemical Engineering Industries

THE analysis made at that time showed that these industries account for approximately three-quarters of the total consumption of the principal heavy chemicals used in the United States.

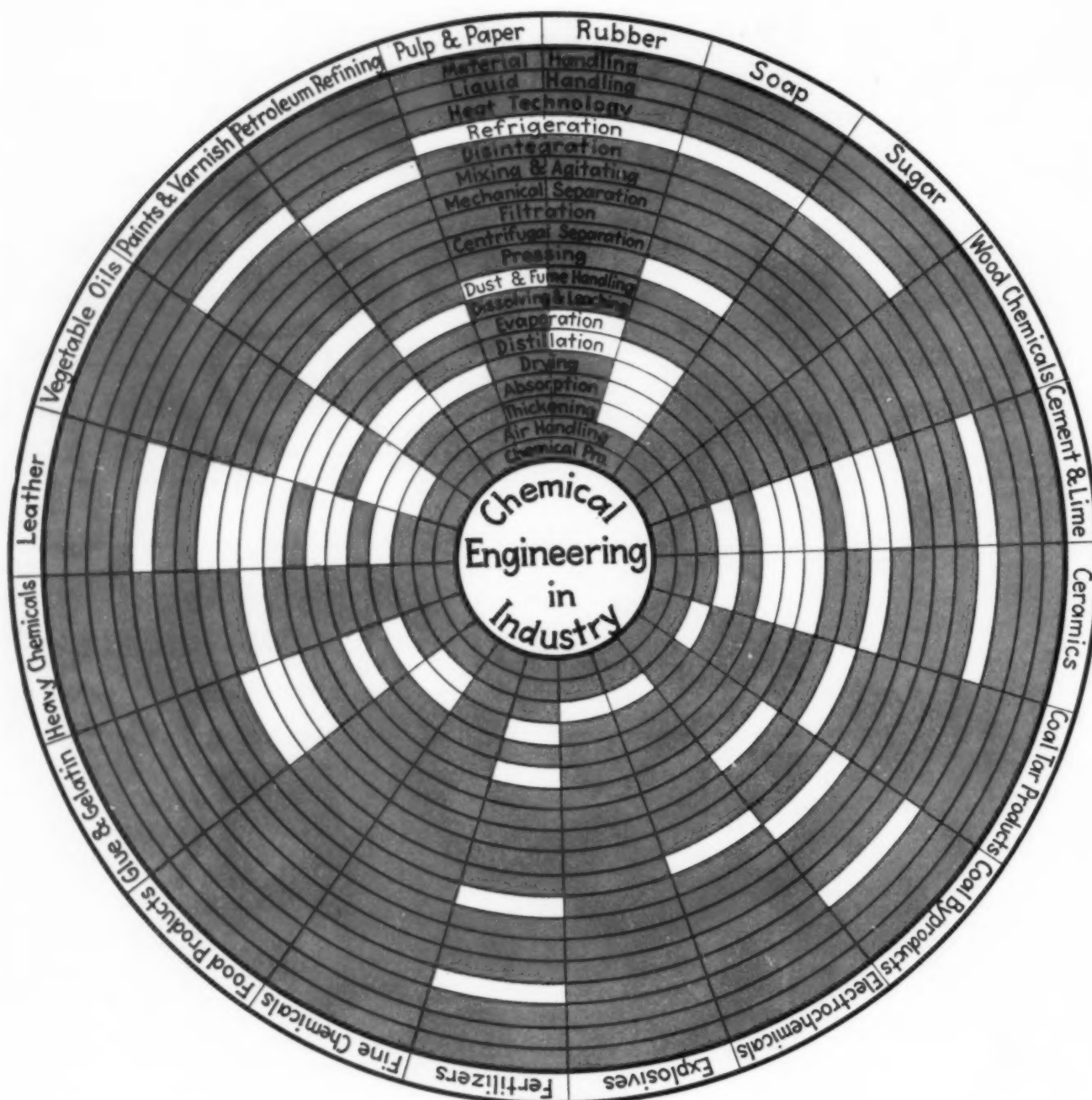
CHEMICALS BY CONSUMING INDUSTRIES

Industries	Value of Output (Census of 1925)	Cost of Raw Materials Consumed	Estimated Cost of Chemicals Consumed
18. Clay Products.....	444,808,445	133,938,840	8,500,000
19. Matches (1923).....	23,940,000	11,786,000	5,000,000
20. Inks, Printing and Writing.....	40,837,000	18,477,000	4,000,000
21. Acids, Sulphuric, Nitric and Mixed.....	23,307,000	11,066,000	3,700,000
22. Gas, Manufactured.....	455,460,000	178,423,000	3,500,000
23. Oil Cloth and Linoleum.....	95,526,320	48,582,253	3,300,000
24. Wall Plaster.....	90,957,000	39,553,000	3,000,000
25. Sugar Refining.....	752,406,794	648,520,716	2,500,000
26. Glue and Gelatine.....	25,764,000	15,338,000	1,500,000
27. Corn Products.....	132,897,974	93,063,575	1,500,000
28. Tanning Materials.....	34,784,000	22,763,000	1,200,000
29. Oils, Vegetable and Animal.....	264,172,000	211,327,000	1,000,000
30. Cements.....	300,895,000	114,169,000	750,000
31. Wood Chemicals.....	25,283,000	15,824,000	500,000
32. Naval Stores.....	42,364,413	11,887,395	250,000
Total.....	\$23,786,111,000	\$4,731,985,000	\$773,400,000

mercial fertilizers. Similar inter-relations are to be found in practically all of the industries. The production of dyes and coal-tar products is probably the best example of successive stages of manufacture, one selling to another in order to produce in the end an elaboration of finished products.

THIS elaboration of products has largely accounted for the phenomenal growth of the chemical engineering industries and it also offers a most encouraging commentary on the possibilities for further expansion. There have been many demonstrations of the relative ease with which the chemical manufacturer can piece together his own intermediate or semi-finished materials in order to produce entirely new products. Bakelite, Duco and rayon are a few of the many names that chemical engineering has firmly fixed in our industrial vocabularies. To say that these have merely replaced standard commodities of commerce is not a true measure of their usefulness. By producing products that never before existed and by devising new and more economical processes for established production, research is greatly increasing the chemical purchasing power of American industry.

INDUSTRY'S COMMON BOND



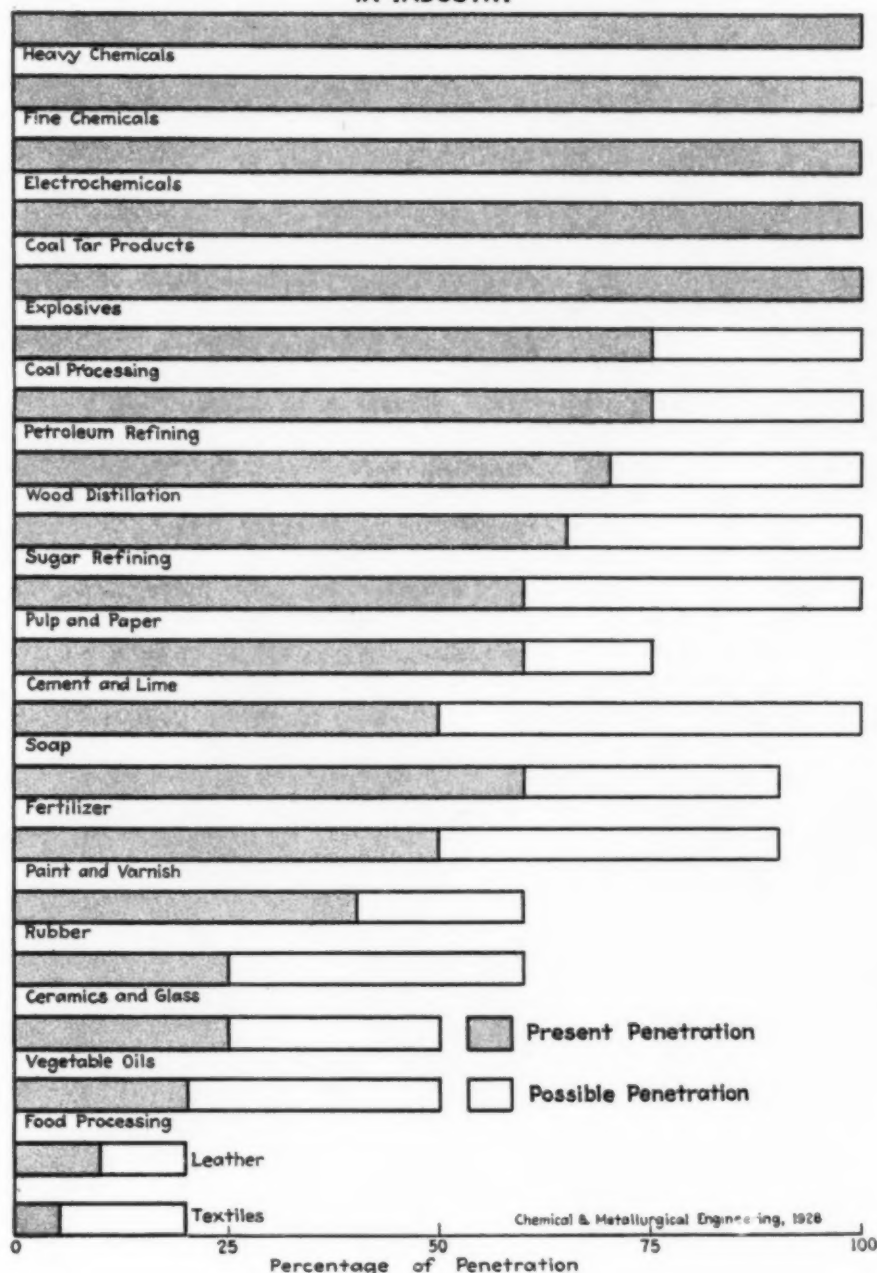
CHEMICAL ENGINEERING finds its expression in industry through the application of certain unit processes that are common to the manufacturing operations in an important group of the nation's industries. Fundamentally the technology of this group of industries is identical. They face the same production problems, which are met through the use of the same equipment and by the same operating methods.

The chart on this page helps to visualize this common bond of technology that ties together the chemical engineering group. Such diversified industries as the manufacture of soap and explosives or dyes and fertilizers find their common denominator in the unit processes of chemical engineering.

The growing consciousness of this identity of interest is the basis for helpful and effective co-operation within the industries. There is increasing appreciation of the fact that the industries must learn from each other. As each advances its technology, others find corresponding opportunity for advancement. As each takes advantage of the latest and best in process, equipment and operating methods, the production efficiency of the whole group is increased. It is for this reason that *Chem. & Met.* is seeking to create a chemical engineering consciousness, not alone among chemical engineers, but in all of the industries served by them. *Chem. & Met.* maintains a clearing house for the industrial interchange of technical ideas.

D IN CHEMICAL ENGINEERING

PENETRATION OF CHEMICAL ENGINEERING
IN INDUSTRY



LACKING a comprehensive occupational census of chemical engineering personnel in the various industries, the editors of *Chem. & Met.* have here attempted to gage the relative penetration of chemical engineering in the different fields. The estimates shown in the accompanying chart are based on editorial studies that have been in progress for a number of years and their approximate accuracy has been checked by the observations of those who have followed the recent progress of chemical engineering in the various industries.

In the strictly chemical industries, such as those producing heavy chemicals and fine chemicals, electrochemicals and coal-tar products, it may be said that there is complete recognition of chemical engineering and that

production is entirely in the hands of chemical engineering or chemically trained personnel. In other industries of the group the chemical engineer has, as yet, a lesser influence. On the basis of 100 per cent for the chemical industries, it is estimated that 75 per cent of the possible penetration has been reached in the petroleum refining and coal processing fields.

In a number of industries there is a predominance of mechanical and electrical rather than of process operations that limits the extent to which chemical engineering may be a production factor. This has been taken into consideration in arriving at the estimates given here for the possible future penetration of chemical engineering in industry.

INTER-DEPENDENCE

Reflected in

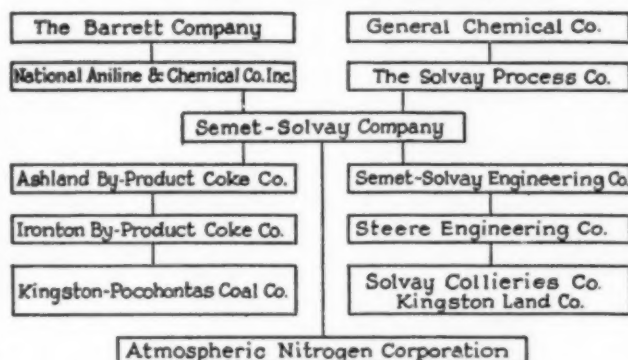
GREAT CHEMICAL CORPORATIONS

ECONOMIC advantages accruing from the close inter-relations of raw materials, processes and personnel have resulted in the development and rapid growth of large corporate organizations within the chemical engineering field. In Europe, particularly in Germany, these organizations have taken the form of huge cartels or horizontal trusts in which all of the producers in a certain industry combine in order to obtain control of commodity production and distribution. In the United States, on the other hand, the principal integration has been of a vertical character, developing through the consolidation of firms controlling various stages of manufacture from raw materials to finished product.

THE amazing ramifications of the great German chemical combination are to be seen in the organization chart on the preceding page. One hundred and fifteen firms are shown to have been merged or in some way affiliated with the I.G. Through many of these there have developed international relations and operating agreements extending to the great chemical corporations of other industries. Two of the latter that have figured most prominently in the reported plans for a world chemical entente are the Imperial Chemical Industries, Ltd., of Great Britain and Les Etablissements Kuhlmann of France. Organization charts for these industries are shown on the following page.

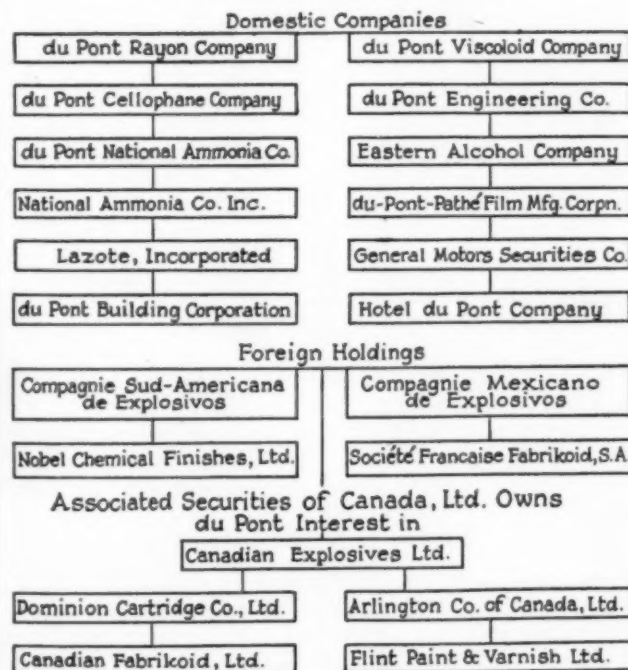
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Total Assets (Dec.31,1926)\$337,675,836



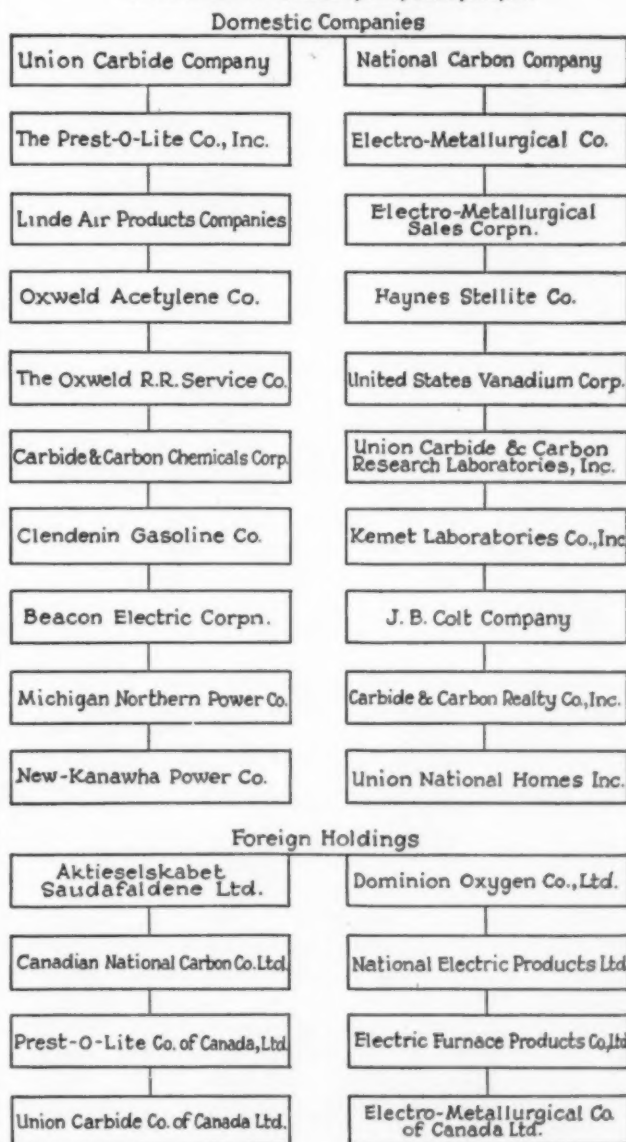
E. I. du PONT DE NEMOURS & COMPANY

Total Assets (Dec.31,1926)\$322,583,674



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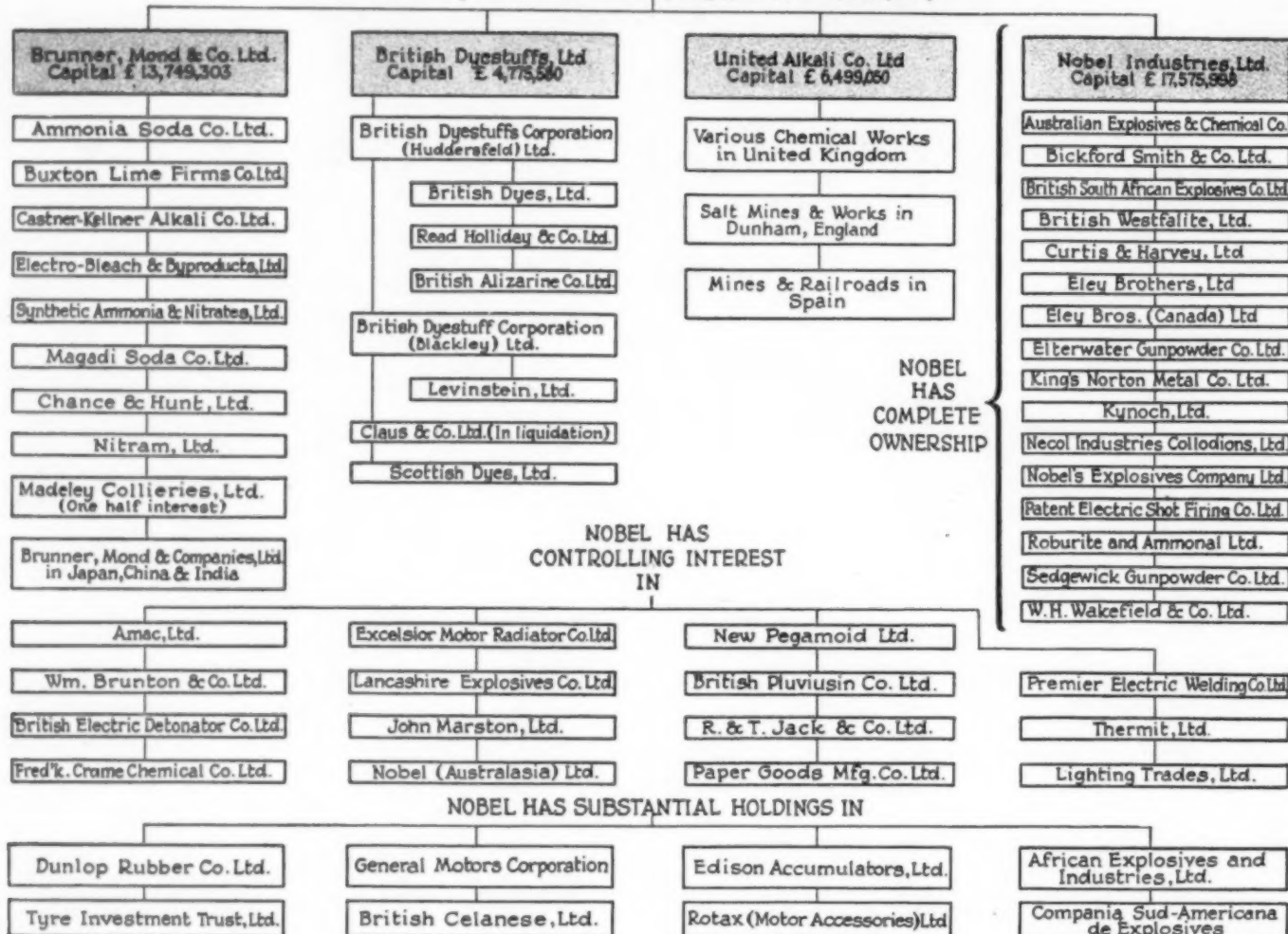
Total Assets (Dec.31,1926)\$238,399,367



—Based on data from Poor's Manual of Industrials for 1927.

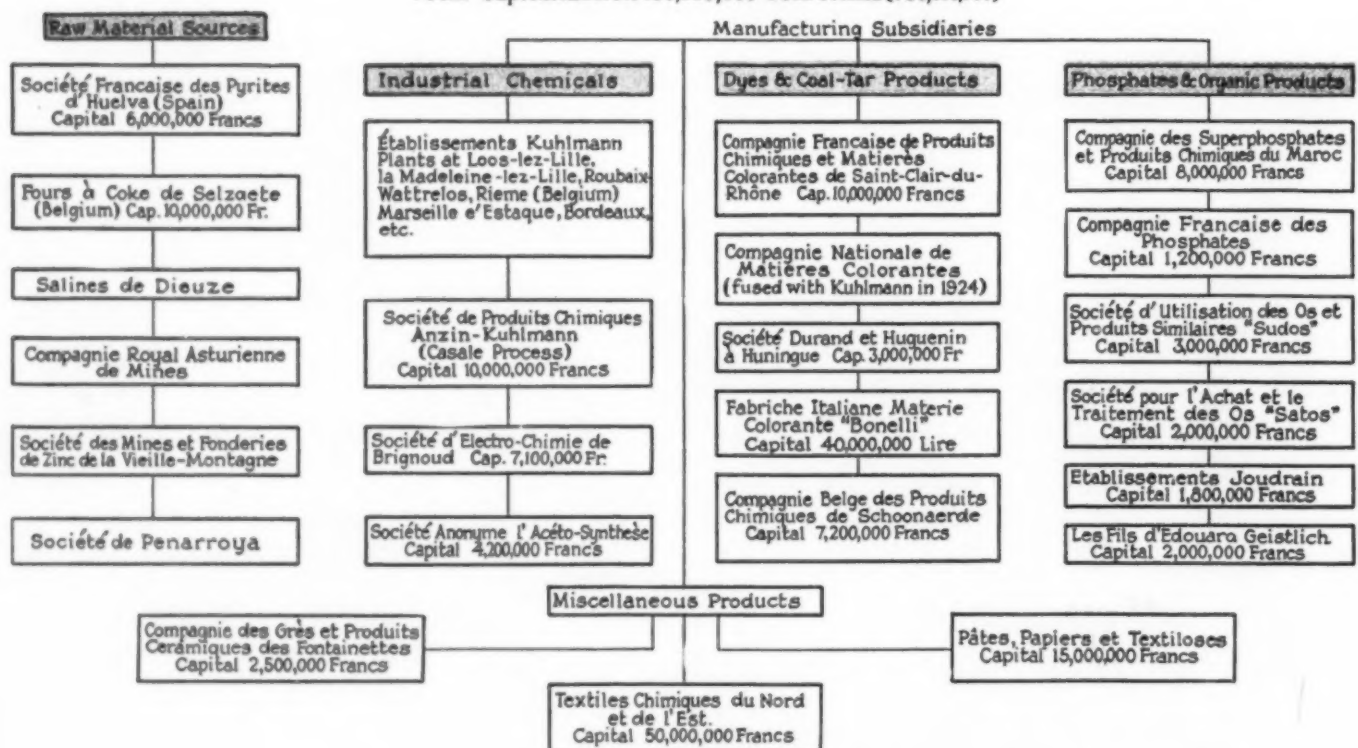
IMPERIAL CHEMICAL INDUSTRIES, LTD.

Total Capitalization £ 42,549,931 (\$ 207,643,650)



LES ÉTABLISSEMENTS KUHLMANN

Total Capitalization 190,000,000 Gold Francs (\$36,670,000)



—Based on information supplied by the Chemical Division,
Bureau of Foreign and Domestic Commerce, U. S. Department of Commerce

Chemical Engineers for Industry

Development of chemical engineering to its present professional status has resulted from the harmonious co-ordination of education, technical literature and useful service to American industry

By H. C. PARMELEE



ONE OF MY CONFRERES has amused himself by collecting, as a byproduct of his editorial investigations, a list of self-styled "engineers" engaged in the manifold phases of the day's work. No fewer than 239 genera and species of these artisans and craftsmen now offer "engineering" service to an indiscriminating public. Their titles run the alphabetical gamut from "adhesive" to "wrapping," from "amusement" to "window shade." Even the humble rolling pin is thus exalted, though to what use is not indicated. Nor are the less tangible elements of life neglected. "Aesthetic" and "spiritual" engineers are available on call to those who feel the need of expert guidance and counsel.

In this welter of engineering, this epidemic of professional aspiration, the chemical engineer is likely to be submerged, or at best assigned to a place in the fire department by a generation that still faintly recollects the advent of the chemical engine. Lacking that intimate professional contact with people enjoyed by the physician, for example, the chemical engineer's place in the world and his relation to national and personal welfare are

only vaguely comprehended by the great majority.

In the realm of industry, however, the situation is happily different. No discussion of chemical engineering in industry, such as is presented in this issue, can be complete without considering the chemical engineer himself, his antecedents, education and broad adaptability. He is at once partly the product, partly the creator of the industrial era. He has evolved out of conditions that demanded his services, and has in turn created an ever widening opportunity where once he was unappreciated. The potential scope of his industrial worth looms larger rather than smaller.

The development of chemical engineering in this country has been fortunate in many respects, not the least of which has been the close cooperation for 20 years between industry and education in expressing and meeting, respectively, the need for the chemical engineer. Industry found chemistry well developed as a science and ahead of its industrial application. The condition is well expressed by Mr. Wickenden in one of the reports of his investigation of engineering education. Contrasting the educational situa-

tion between the older and newer divisions of engineering, he said: "Engineering education in the civil, mineral and mechanical fields began as a race on the part of science to overtake a pre-existing art, with the practitioner type as a ready-made model for educational effort. In the electrical and chemical fields of engineering, science has consistently gone in advance of the art, with the result that the aim of education has been not so much to reproduce the practitioner as to adapt the scientist into the practitioner."

It is this need of the practitioner—the chemical engineer—of which industry became conscious a score of years ago, and which education successfully undertook to satisfy. Further testimony to the point is found in a recent statement by Sir Alfred Mond, Chairman of Imperial Chemical Industries, Ltd., in the course of an address on the chemical industry: "In the past the chemist has probably claimed and received rather more than his share of credit for the success of our industry, which frequently offers greater difficulties to the engineer who puts it into practice than to the chemist who originally worked it out in the laboratory. Good engineering can often turn an unprofitable chemical process into a profitable one."

Out of this recognition has grown a system of education that prepares chemical engineers to adapt their scientific knowledge and engineering principles to practical industrial ends. This education is not intended to fit men for particular tasks but rather to inculcate a system of related knowledge that will be broadly applicable. The scientific groundwork is chemistry, physics and mathematics, on which is superimposed a quantitative study of those

physical and chemical operations used in industrial plants. The result is that today a score or more of technical schools and universities have developed sound courses in chemical engineering and have gained recognition for it as one of the major divisions of engineering.

WHAT of the product? How well does the chemical engineer measure up to the expectation of being broadly useful in industry? How widely can he actually apply his general knowledge to special production problems? One answer is found in the employment records of successful chemical engineers. Not only are men with the same educational background found in a score of industries, but a single individual by actual record has been engaged successively in coal processing, metal refining, pigment production and explosives manufacture. Another in leather production, equipment design and the making of fine chemicals. And still a third in charge of the manufacture of heavy acids, explosives, alkalies and pyroxylin plastics. The record could be multiplied, covering the industries making dyes, rubber products, lacquers, refractories, paper and numerous other products. As a whole it is impressive evidence of the utility of the chemical engineer and a tribute to the efficiency of his education.

Being comparatively young, chemical engineering has lacked an adequate book literature, but this deficiency is being rapidly met. Here again industry and education are collaborating in the production of correlated text and reference books. Leaders of thought in teaching and practice are formulating the underlying principles and their industrial ap-

EMPLOYMENT RECORDS OF TEN TYPICAL CHEMICAL ENGINEERS IN INDUSTRY

	SUCCESSIVE POSITIONS HELD	INDUSTRY IN WHICH EMPLOYED
1	Ass't. Superintendent Chemist Superintendent Works Manager Superintendent	Water Gas Paint and Varnish Dyeworks Electrochemicals Fine Chemicals
2	Research chemist Superintendent Superintendent Ass't. Superintendent	Byproduct Coke Metal Refining Lithopone M'fg. High Explosives
3	College Professor Chemical Engineer Superintendent Vice-President	Organic Chemistry Indigo Manufacture Coal-tar Chemicals Dye Manufacture
4	Chemical Engineer Engineer of Design Chemical Engineer Chemical Engineer Plant Engineer Consulting Engineer	Leather Tanning Equipment M'fg. Fine Chemicals Asphalt Fine Chemicals Chem. Engineering
5	Foreman Superintendent Ass't. Superintendent Superintendent Plant Engineer	Electrochemicals Coal-tar Products Synthetic Phenol Explosives Fine Chemicals
6	Chemist Foreman Superintendent Superintendent Superintendent Plant Manager	Electrochemicals Iron and Steel Sulphuric Acid Explosives Caustic Soda Pyroxylin Lacquers
7	Chemical Engineer Chemical Engineer Superintendent Plant Engineer Chemical Engineer	Matches Dyeworks Sulphur Chloride Electrochemicals Rubber
8	Research Chemist Chemical Engineer Chemical Engineer Superintendent Construction Engr. Plant Engineer	Byproduct Coke Pulp and Paper Fine Chemicals Dyeworks Poison Gas Plant Fine Chemicals
9	Wood Paving Inspector Development Engr. Chemical Engineer President Superintendent	New England City Coal-tar Products Pharmaceuticals Consulting Engineers Dyeworks
10	Operator Chemist Sales Engineer Superintendent	Coated Paper Iron and Steel Equipment M'fr. Beet Sugar Plant

plication in a manner that indicates unity of purpose and makes for solidarity and efficiency. This literature bids fair to grow extensively and become a powerful factor in the teaching and practice of chemical engineering, as it covers not only the principles but their application to the profitable production of a vast variety of commodities. Add to this the current literature of societies and magazines, and the total makes an effective professional tool.

With his college curriculum, his industrial field and his technical literature thus harmoniously coordinated, the professional aspirations of the chemical engineer find expression in the American Institute of Chemical Engineers. Qualified by training and experience, and bound to observe a code of ethics, the members of this organization exert a beneficent influence on the character and conduct of the profession. They take a lively interest in technical education. Through interchange of experience they broaden one another's horizon to the advantage of themselves and their industries.

From this brief consideration it must be apparent how important to industry are the first of that trinity—men, methods and materials—that determine the inter-dependence of the chemical engineering industries. Broadly differentiated from other engineers, for reasons of educational efficiency and industrial utility, chemical engineers find a distinctive and legitimate field for their services. Time was when reason for their existence was questioned, when they were disparagingly dubbed "pipe fitters." But they have emerged from that period of trial with a prospect that is as bright as that of American Industry itself.

Chemical Engineering Pervades All PETROLEUM Technology

By ARTHUR D. LITTLE

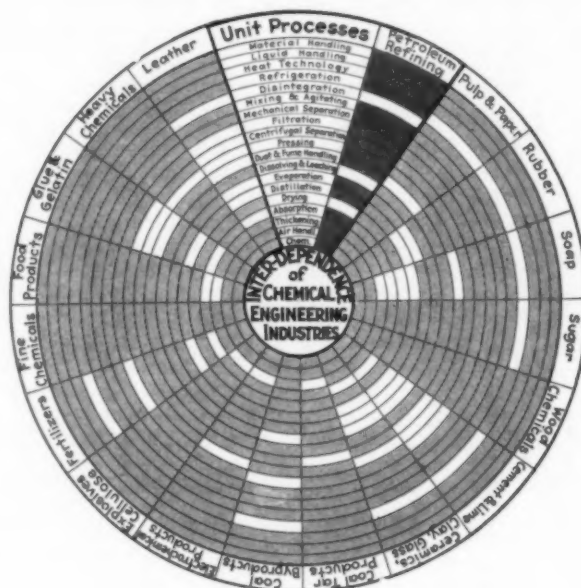
President, Arthur D. Little, Inc.,
Cambridge, Mass.

THE PETROLEUM INDUSTRY is working with constantly increasing acceleration toward a scientific basis. There are many evidences of the newly awakened appreciation of the scientific method and the value of research,—an appreciation which is undoubtedly animated by the present narrow margins of profit and the competition resulting from the exceptional activity in all branches of the industry. Among these evidences we may mention the comparatively recent organization of the American Petroleum Institute and the Institution of Petroleum Technologists (London), the \$500,000 research fund established by Mr. Rockefeller and the Universal Oil Products Company, and the heavy draft of chemists and chemical engineers which the industry is making on our technical schools.

To instance the Massachusetts Institute of Technology alone, there have been drawn by various oil companies from its Research Laboratory of Applied Chemistry such exceptionally qualified professors as R. E. Wilson, R. T. Haslam, Walter G. Whitman, Leon W. Parsons, R. P. Russell, and among others of its instructing staff, Daniel P. Barnard, Brian Mead, William L. Asbury, Edwin J. Gohr, W. V. Hanks, and D. A. Shepard. While such men are undoubtedly now serving the industry to great advantage, it may be questioned whether in the long run the higher interests of the industry might not be better served by co-operating with the institutions in the up-building and support of strong departments for the training of men to meet its broad requirements.

The petroleum technologist, who is of necessity a chemical engineer, has to deal with whole series of hydrocarbons, ranging in character from natural gas through liquids of increasing density to the heaviest lubricating oils and solid paraffin, with coke as a final product. The conditions under which these materials are handled and treated, the high temperatures and pressures commonly involved, the risks of fire and explosion, and the very serious problems of corrosion call for chemical engineering of the highest type if operations are to be conducted safely and efficiently. These inherent hazards and difficulties are further complicated by the enormous volumes of material which must be handled, the nicety with which components must be separated, and the high degree of purity demanded of many of the products. Chemical engineering begins in the field, and it does not end at the refinery, for at least one of the larger companies is recruiting its sales force from chemical engineers. It is also coming to be recognized that the selling of high grade refinery and other equipment has become a job for the engineer rather than one for the salesman.

With the depth of wells constantly increasing and at least one,—“Olinda 96”—down more than a mile and a half, the problems of the petroleum technologist in the



field become more and more difficult and the chemical engineering aspect of many of them increasingly apparent. They now involve the use of the compressed-air lift, which lightens the column of liquid and in some cases quadruples the flow, as exemplified in the Seminole field; the still more advantageous natural-gas lift, similarly used in the Los Angeles Basin and elsewhere; the flooding system of increasing flow by the introduction into the well of water or of sodium carbonate solution; the breaking of emulsions, in itself a pretty problem in physical chemistry; and the troubles due to clogging by wax, as with the paraffinoid oils in Texas.

Since it is generally agreed that the oil left in the sands in “exhausted” fields is at least several times that secured by flowing and pumping, and since the tenacity with which it is retained by the sands must be in large measure determined by the viscosity and surface tension of the oil, studies of the factors influencing these two properties are of first importance for the industry. Research recently conducted under the direction of Henry L. Doherty has demonstrated that at a pressure of 50 pounds and a temperature of 70 deg. F., a natural gas of the type associated with the oil reduces the viscosity of the oil about 50 per cent when a given crude is saturated with the gas. At the bottom of the deeper wells pressures of 1,800 pounds or more may exist and effect further substantial reductions of viscosity.

Similarly, the surface tension of crude oil is found to be reduced by the dissolved gas to the extent of approximately 20 per cent at pressures from 400 to 500 pounds.

In at least one field the sulphuretted hydrogen in the gas reaches such proportions that operators are required to wear the gas masks which are a product of the Chemical Warfare Service, while of far greater importance from the economic standpoint are the very serious problems of corrosion from sulphur in its various forms, and from salt water, magnesium salts, and especially from

the chloride in view of its tendency to hydrolize with the formation of hydrochloric acid. One hundred thousand barrels of certain crudes may contain as much as 650,000 pounds of sulphur. At the recent meeting of the American Petroleum Institute, its Corrosion Committee reported that the evidence obtainable indicated an annual loss to the petroleum industry, from corrosion alone, in the field, pipe line, storage, refinery and marketing, of \$125,000,000. When we add to this an estimated fire loss to the industry, of \$1,044 per minute, in 1925, it is obvious that the chemical engineer has still much work ahead.

While he cannot hope to remove the enormous amounts of sulphur present in our vast production of oil, he has found that the addition of ammonia or other forms of alkali helps in special cases, to minimize corrosion problems, and further progress has been made through the use of chemical engineering equipment, special alloys, and so on. The high resistance of chromium to sulphur and other corrosive agencies, and the fact that carbon does not readily adhere to this metal, have justified the expectation that the recently developed methods of chromium plating might prevent the corrosion of equipment. It appears, however, that further improvement in plating methods may be necessary to overcome an observed tendency of the plating to chip.

STILL OTHER chemical engineering problems are presented in the heavy evaporation losses now suffered in handling and storage. These are estimated to reach one billion gallons per year. In the Bradford, Pennsylvania, field the evaporation losses on the high volatile oil there produced may reach a maximum of 18 per cent, but it is significant to note that methods and precautions now being introduced, have demonstrated that this loss may be cut down to one-half per cent. Throughout the industry, evaporation is being minimized by such devices as breathing bags and floating roofs for storage tanks, and the employment of aluminum and zinc oxide paints to cut down heat absorption. For this purpose aluminum paints seem most effective in direct sunlight, whereas zinc oxide paints appear to function most efficiently at night, and on the whole, to be presumably better during the twenty-four-hour cycle.

The development of chemical engineering methods involving compression or absorption in oil or charcoal now permits the recovery in a single year of a billion or more gallons of casing-head gasoline. Its "wild" fractions were formerly and are still to a large extent weathered off. A serious effort at their recovery is, however, now in progress, and these fractions are finding employment as special solvents, as the raw material for chemical syntheses, and in regulated proportion as advantageous blending agents to raise the volatility of gasoline. Compressed in cylinders, these fractions are finding a market for the heating and lighting of isolated country homes. It has been found that butane in amounts up to eight per cent may advantageously be contained in gasoline, provided no propane is present. Small amounts of propane seriously and objectionably increase the vapor pressure of the gasoline.

The results of the recent application of chemical engineering methods is nowhere more apparent than in the oil refinery, though in most instances these methods have been previously developed and their efficiency demonstrated in other industries. So radical have these improvements been that one refinery is reported to have scrapped a third of its apparatus within five years.

Batch operation is being replaced by continuous or semi-continuous methods which commonly involve the change from shell stills to pipe stills. The latter have the advantage of greater heating surface, better transfer of heat, better control of temperature, and greater throughput capacity. Radiant heat is being called upon to do more and more work, as tubes containing oil cool the furnace walls as water tubes do in modern boilers.

The introduction of modern separating equipment has reduced re-running 75 per cent in some refineries. The use of bubble towers appears to offer the greatest possibilities in this respect, since to the advantage of closer fractionation, less re-running, and substantial economy, they add the even more important factor of flexibility.

AT LEAST two processes are now in operation for distillation under high vacuum for the production of lubricating oils of superior appearance and quality. In one instance, the serious engineering difficulties incident to continuous pipe-still operation at 2 or 3 mm. pressure have been worked out. The use of electric-welding equipment is increasing, and the factor of safety is being further raised by the employment of forged containers of large size which can now be obtained in this country. The effect of sulphuretted hydrogen in distilling equipment is not of itself serious, since it forms a protective coating of iron sulphide, but water or hydrochloric acid causes this coating to peel off and, if present, permits the continuous attack of the metal. Since the hydrochloric acid commonly results from the hydrolysis of magnesium and calcium chlorides, the remedy is to keep the stills free from water and these compounds. At the higher temperatures of cracking operations, however, sulphuretted hydrogen alone is seriously destructive. The application of red lead paints on sandblasted surfaces has recently been shown to afford protection to storage tanks from sulphuretted hydrogen.

Among the many other unit operations with which both chemical engineering and petroleum technology are concerned, mechanical refrigeration finds its place. It is required for the condensation of light fractions and for the chilling of wax distillates, and has very recently found application in a method of treatment developed for the refining of high sulphur crudes of California, in which the oil is chilled below zero Fahrenheit as a preliminary to the admixture of sulphuric acid in successive small additions, the oil being again cooled after each addition. The acid required for treatment has thus been reduced over 40 per cent, and the treating and polymerization losses by 30 and 70 per cent respectively.

IN THE METHODS of sulphuric acid treatment generally employed, heavy losses are entailed, and the acid as applied to gasoline removes much of the desirable anti-knock material. There is also the general nuisance involved in the disposal of acid sludge and the recovery of the acid itself. The amount of this acid used by the industry during 1926 reached a total of 1,510,000 tons. A number of refineries are now making their own acid by the contact process and, as an incidental advantage, are building up the strength of diluted acids by the addition of sulphuric anhydride. Constant effort is being made to minimize the use of sulphuric acid by alternative methods of treatment, as, for example, by subjecting distillates in the vapor or liquid phase to the action of fullers earth. For this purpose the Gray tower has recently become available.

The Bergius process for the conversion of coal to

oil, by hydrogenation under high pressure, appeared initially to have little interest in a country like our own, embarrassed by a flood of oil. The possibility of its application to the conversion of heavy oils and residues into lighter fractions has, however, led to the recent acquisition of the process by one of the Standard Oil Companies, at whose hands the commercialization of this phase of its development may be expected.

THE rapid evolution of refinery equipment and the succession of new processes furnish direct evidence of the pervading influence of chemical engineering on the petroleum industry, and since combustion and heat transfer are subjects with which chemical engineering is primarily concerned, this influence is extending its beneficial effect to methods involving the use of fuel in refineries. The general application of the principles of thermodynamics, the utilization of the sensible heat of exit products, the introduction of heat exchangers, superheaters and automatic controls, enabled the refineries to conduct their operations in 1926 with 4,000,000 barrels less fuel oil than they used in 1925. There are still many serious sources of fuel waste in refineries, and it should be possible to utilize as much as 60 to 70 per cent of the sensible heat in the materials processed.

There have been many proposals for the employment of molten metals, usually lead, as aids in heat transfer in refinery equipment, but these have seldom passed beyond the experimental stage. In one refinery, however, mercury vapor stills were recently installed.

Gasoline, which was once a nuisance to the refiner, has now, as everybody knows, become his most important product and the motivating agency of ubiquitous systems of transportation on land and water and in the air. About 12,500,000,000 gallons were used in 1926 in this country. A remote conception of what that means in terms of energy may be derived from the fact that the potential energy of one gallon of gasoline is 93,360,000 ft.-lb. Only about 5 per cent of this energy is actually utilized to push an automobile. Of the remaining 95 per cent, one-third is lost in cooling water, rather more than one-third in the exhaust, and the balance in friction and radiation losses. Such disproportionate losses are obviously a challenge to the chemical engineer.

The operation of cracking, by which light distillates are developed from heavier oils, is estimated to have doubled the amount of gasoline previously obtainable from the crude oil. From the motor fuel standpoint, therefore, the effect has been equivalent to a doubling of the supply of crude. The first contribution of industrial importance to the art of cracking was the well known Burton process, through which in its various modifications, the supply of cracked gasoline was mainly derived for many years. Its success so stimulated inventors that proposals for a bewildering number of other processes followed. We have in our petroleum library more than five thousand petroleum patents. By far the greater proportion of these relate to cracking processes, most of which have proved abortive, but out of this number have come a few processes such as those of Dubbs, Cross, and Holmes-Manley, which are generally replacing the earlier methods. These latter processes operate at much higher pressures, which may reach 1,000 pounds, and the design of their equipment calls for chemical engineering of the highest order. Very recently, by improved methods of operation, the daily throughput in some of these plants was doubled without increase of unit size.

In automobile engines the present trend is toward

higher compressions and the more economical use of gasoline. The old Ford got 15 to 21 miles from a gallon of gasoline, whereas 30 miles per gallon are claimed for the new Ford car. It would appear from this that the 15,000,000 cars of model "T" have made a heavy and needless drain upon our gasoline supply.

With the higher compression now demanded, the anti-knock problem has become one of the most important to the designer and driver of cars, and of equal concern to the refiner. A few years ago the gasoline of highest rating was from straight run Pennsylvania crude. It was sweet, water white, and of high Baumé test. Today, anti-knock quality is of far more importance than color, odor or gravity. The straight run gasolines from paraffin crudes, which formerly dominated the market, are now recognized as the worst knockers. Asphaltic base crudes, as those of California and Russia, yield gasoline of far better quality when judged by present standards, although they are much lower on the Baumé scale.

The advantages of high compression in automobile engines are so obvious and many, that an enormous amount of research and chemical engineering effort has been expended in attempts to raise the anti-knock quality of gasolines. The addition to the gasoline of benzol in substantial proportion has proved highly effective, and is now widely used. Aniline is still more efficient in this respect, but too expensive. Tetra-ethyl lead, developed after long and arduous research, eliminates knocking, but a more satisfactory and permanent solution of the problem would seem to lie in the careful choice of crudes and methods of cracking and refining.

Whereas the cracking processes now generally in use operate on material in the liquid phase, the superior anti-knock properties of gasoline produced by vapor-phase cracking have drawn this latter method into recent prominence. Vapor-phase gasoline is highly unsaturated, —perhaps to the extent of 60 per cent—but this alone can hardly account for its extremely high anti-knock quality. It is possible, therefore, that branched chain compounds and perhaps cyclic compounds present in such gasoline may be still more important in this particular.

The troubles caused by the separation and deposition of carbon in the earlier cracking processes, and which have led to elaborate provisions for its convenient handling in the later liquid-phase processes, attended and complicated the earlier vapor-phase development. Our own laboratory has, however, developed and operated on a small commercial scale a vapor-phase process with a 45-day operating cycle without deposition of carbon.

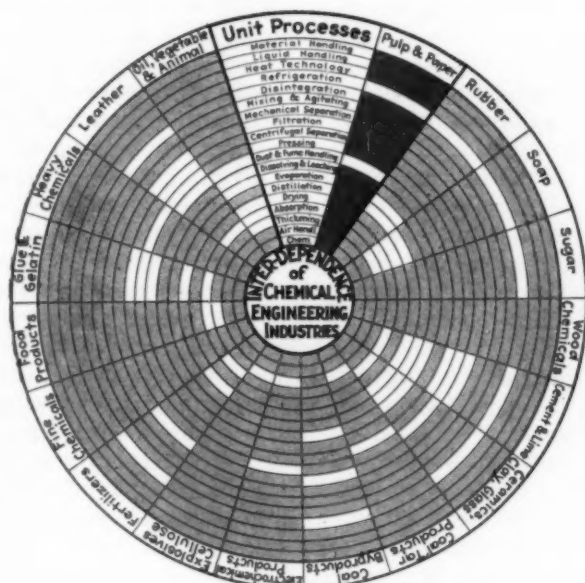
IN THE PAST, the relation of the petroleum industry to the chemical industry has been that of a consumer. It has called for 1,500,000 tons a year of sulphuric acid and for caustic soda and sodium carbonate in large amounts. It has made use of lime and ammonia, calcium hypochlorite, liquid sulphurous acid, and sodium plumbite. It has always been a large consumer of paints. There is now accumulating evidence that the industry is soon to function as a contributor of new solvents and organic chemicals in great variety, obtained through the application of synthetic processes based on petroleum derivatives. The great industries developed from coal tar had their foundation in the intensive German study of the benzenoid hydrocarbons. The extraordinary activity now shown by American chemists in their study of the aliphatic compounds may soon provide the basis for equally great chemical industries based upon petroleum.

PULP and PAPER Industries

Based on Applications of Unit Processes

By

By JOHN D. RUE
Champion Fibre Company,
Canton, N. C.



THE PULP AND PAPER industry was long considered one which was operated by "rule of thumb" methods. There are mills even today in which such methods predominate but their number is decreasing and they constitute the minority. Fifteen years ago the chemists and chemical engineers in the United States mills were found mostly in the laboratories; now many of them hold important executive positions, a fact which is in large measure responsible for the more rapid application of sound principles of chemical engineering practice to the manufacturing operation of the industry in recent years.

That the pulp and paper industry is truly a chemical industry is suggested by the long list of chemicals which are consumed in its processes of manufacture. Sulphur, lime, limestone, dolomite and soda ash enter into the manufacture of pulp by the sulphite process and processes related to it. Soda ash and lime are used in the soda process; liquid chlorine, lime and hypochlorites in bleaching. In the processes by which pulps are converted into paper, there is a long list of chemicals which are used to a greater or less extent: Sulphate of aluminum (paper makers "alum"), sodium resinate (size), glue, sodium silicate, starch, clay, casein, calcium sulphate, barium sulphate, numerous dyes both mineral and organic, and many others.

Added evidence of the chemical nature of the industry is found in the numerous chemical transformations which take place in its processes. Sulphur is burned to SO_2 and the latter absorbed by lime, limestone, dolomite, or soda ash to form bisulphites, sulphites, sulphurous acid and mixtures of them; soda ash is causticized with lime; saltcake is reduced to sodium sulphide; chlorine is converted into hypochlorite; not infrequently salt is elec-

trolyzed to produce chlorine for local consumption and caustic soda for distribution; occasionally hydrogen, a byproduct of the electrolytic process becomes the raw material for some local chemical process by which other chemical products are made for the market; occasionally also tannin is made as a byproduct of the pulping operations; frequently turpentine is produced as a byproduct of the sulphate pulp mill; sodium resinate is made to react with aluminum sulphate in the sizing of paper and is used with glue in a manner to render the latter insoluble when deposited and dried upon the fibers; casein and glue are made the basic cementitious constituent in the composition of mineral coatings for paper.

The chemical processes enumerated in the preceding paragraph are for the most part not peculiar to the pulp and paper industry. As basic chemical reactions they are merely adapted to the needs and purposes of the pulp and paper manufacturer. The chemical desintegration of wood by the various processes of digestion is, on the other hand, especially characteristic of that industry as are also the processes by which the fibers are bleached and purified in their preparation for use in the paper mill.

In the manufacture of paper from the pulp, the chemical nature of the operation is frequently lost sight of in the maze of intricate, extensive and delicate mechanical operations which are required. Those mechanical operations have as their chief objective, however, the modification of the colloidal properties of the fibers, the distribution of the fibers into a wet mat or sheet, the development of cohesion between the fibers by pressing, and the removal of water and the breaking of the colloid by means of heat. Related to the major reactions are various side reactions such as the coating of the fibers with water resistant materials, the hydrolytic disintegration of the fiber by means of heat or the action of acid, or the effect of electrolytes in the water suspending medium upon the colloidal nature of the fibers. Some of these side reactions are desirable and some are to be avoided; all should be controlled, as their effect upon the quality of the product may be vital.

Even the more abstruse reactions which belong to the realm of colloid chemistry are claiming the attention of the men of the industry. It is not uncommon these days to hear not only the plant chemist but the works foreman and their helpers talking of their operations in terms of pH variations.

In addition to the strictly chemical processes there are many unit processes represented in pulp and paper manufacture which in basic principle are common to many industries. A brief review of some of those unit processes will indicate something of the degree to which developments in other industries have an important bearing upon the pulp and paper industry.

LARGE quantities of steam are required for digesting the pulp, for drying the paper, for raising the temperature of the suspension preliminary to bleaching and for heating water to be used for washing pulp. Important fuel economies have been effected by recovering the heat escaping with the relief gases from the digesters; that, in a few cases, from the steam which escapes at the time the contents of the digester are blown; that in the condensate from the "black liquor" evaporators; that in the stack gases from boilers and from "black liquor" incinerators, and more recently, that which escaped to the atmosphere in the warm air which is passed over the paper machine dryers. An outstanding recent development in heat economy in the pulp and paper mill is the steam accumulator which aids in equalizing a fluctuating demand for high-pressure digesting steam and co-ordinates it with the more uniform demand for low pressure steam in the paper dryers.

MATERIAL HANDLING is, of course, an important factor in the paper mill.

Wood is conveyed in flumes or on various types of a chain conveyor; chips on belt and bucket conveyors; pulp at times by screw conveyors but mostly in water suspensions of such high dilution and fluidity that the mass can readily be pumped. Pulp is now being transported by the latter method for distances up to four miles.

The concept of water as a conveyor is still rather vague in the minds of many manufacturers. This is evident from the fact that manufacturers of the same grade of product may vary in their consumption of water from as low as 2,500 gallons to as high as 40,000 gallons per ton of paper produced. Failure to return the water in maximum proportions to its function as a conveyor means in many cases loss of valuable fiber through excessive wastage to the sewer, increased steam consumption through the necessary introduction of excessive quantities of cold water and increased cost for chemicals to soften that water, when the supply is hard.

DISINTEGRATION processes are found in the chipping of the wood; in the grinding of wood for mechanical pulp; in the refining of knots and screenings; and in the refining of chemical pulps. For all of these operations equipment has been developed especially designed to adapt it to the needs of the pulp and paper maker and marked progress has been made in recent years in the technical control of the processes, and of the properties of the products resulting from them.

Mixing and agitation become of importance in the preparation of pulp suspensions of uniform consistency; in the uniform introduction of bleach into the pulp suspensions; in the blending of fiber and chemical ingredients preliminary to the formation of the sheet of paper; in the blending of coating mixtures, and in the preparation of emulsions of size and clay.

FILTERING AND THICKENING are two unit processes largely applied in the paper mill. Large quantities of pure water are required and it is not unusual to find filtering plants which have a capacity of from 10,000,000 to 30,000,000 gal. per 24 hours. In some cases artificial coagulation becomes essential to the production of a satisfactory water supply.

Various other filtering operations are met with such as the removal of lime sludge from the caustic liquors. For that purpose continuous suction filters have proven

effective and economical. The transportation of pulp about the mill by means of water suspension necessitates dilution at many points to facilitate pumping and subsequent thickening to prepare the pulp for processing or for storage. The making of the wet sheet of paper is in itself a thickening operation, accomplished by filtering on wire screens, perhaps aided by pressure and by suction. The recovery of pulp and other insoluble material from every dilute suspension is at times effected by settling either with or without the aid of coagulants. The thickened material can then usually be returned to the manufacturing processes and used with profit.

OPERATIONS involving the application of high pressure are numerous. In the process for dewatering pulp suspensions there is used the thickener or decker in which a gentle pressure aids the purely filtering action and results in a product 10 to 15 per cent dry. In the wet machine, pressure, aided by the absorptive action of felts, results in a product varying in dry content between 25 and 45 per cent. Both the thickener and the wet machines operate continuously. For a more complete mechanical removal of water, resort must be had to the hydraulic pressing of the pulp in the form of bales or cheeses. In the manufacture of some types of fiber board, a high density and a high degree of hardness and stiffness are obtained by placing the wet sheets under high pressure for the period during which they are being dried. In the surface finishing of paper a smooth or glossy finish is obtained by the continuous application of very high pressure, by means of calender rolls. When the pressure is thus applied in a suitably pretreated and premoistened paper, transparency or at least a high degree of translucency results and products such as glassine or envelope window paper are obtained. Batch surfacing of the paper is attained by the process of "plating." Alternate sheets of paper and the material whose surface markings it is desired to transfer to the paper are compressed in piles, the layers being interspersed at frequent intervals with smooth metal plates. The degree of fiber plasticity essential to successful plating is attained through a judicious development of hydration in the fiber during the paper-making operations and through maintenance of a suitable moisture content during the "plating" operation.

DISSOLVING or leaching constitutes an important operation in the extraction of soda ash from the "black ash" of the soda pulping process and in the washing of unbleached and bleached chemical pulps. In the leaching of "black ash," counter-current diffusion is the rule.

In the washing of pulps a wide variety of methods are in vogue. Bleached pulp is still washed by percolation or by alternate dilution and thickening, although the continuous suction filter is coming into use for that purpose.

In the manufacture of soda pulp it has been necessary, practically from the outset, to concentrate and incinerate the waste liquors for the recovery of their chemical content. Washing with a minimum amount of water has therefore been vital to economy of operation; yet until very recently "pan" washing by percolation has been the rule. The continuous suction filter has at last found its place in the washing of soda pulp. When the sulphate process was introduced to the industry, long after the soda process had been established, it brought with it the counter-current diffusion method of washing.

Attempts have been made to adapt the continuous suction filter to the washing of sulphate pulp but the results have not been entirely successful. The resinous woods commonly used in that process give rise to resin soaps which are the source of much foam trouble in the suction.

In the washing of sulphite pulp there has been very little incentive to limit the quantity of wash water used. No practicable method has been developed whereby the waste materials can be utilized in quantities at all commensurate with the quantities to be disposed of. The growing necessity of preventing their discharge into streams will undoubtedly result in practicable disposal methods. The need for the development of such methods presents in itself a challenge to the chemical engineer. When the methods are developed he will be confronted with important equipment problems in the collection and concentration of dilute solutions having a strongly acid reaction.

As has already been intimated the problems of pulp washing are closely related to those of the evaporation of the wash waters. At least that is true of the soda and sulphate processes and is likely soon to be true of the sulphite process in which the corrosive properties of the waste liquors greatly enhance the difficulties. It is true that, to a limited extent, sulphite waste liquor is already being evaporated and some of the difficulties at least partly overcome.

DRYING constitutes an important element in the manufacture of paper and also of pulp for shipment. About 2 lb. of water must be evaporated for each pound of pulp or paper dried. Various types of drying equipment are in use. Paper and thin board, because of their flexibility, are dried on batteries of rotating steam-heated drums. Boards of heavier weights are built up by pasting together the thinner plies or, if made in single ply, are dried in kilns after the wet board has been cut into sheets and sometimes in a continuous sheet in very long tunnel dryers.

Aside from the economies involved, drying presents many interesting and difficult problems by reason of the colloidal character of the fibers, and its effect upon such properties of the product as shrinkage, stretch, warping, curling of the edges, opacity, etc. In most cases drying is done by the application of a heated surface to one side of the sheet and warm air of low relative humidity to the other. The applications are frequently reversed during the drying. It is not always easy, however, to distribute the heat uniformly over the surface of the paper or to maintain uniformity of relative humidity in the air in contact with the other side of the sheet. Thick sheets, when dried in this manner may develop different rates of shrinkage on the two sides of the sheets, thus causing warping. In some cases thick sheets are dried by raising their temperature well above 100 per cent relative humidity. By that means the drying rate throughout the sheet is maintained fairly uniform and troubles from warping are reduced to a minimum.

CHLORINE is the active bleaching agent used in producing white pulps and is invariably used in the form of hypochlorite, usually of calcium. It is either made locally or purchased in liquid form and the gas absorbed in milk of lime. It is only within the last ten years that the pulp manufacturer has practically ceased to purchase his hypochlorite in powder form, a change which the production of low cost liquid chlorine has made possible.

Efforts have been made to use SO_2 in the liquid state, but so far it has not been economical to do so. It is invariably made locally by burning sulphur. The products of combustion which contain about 16 per cent SO_2 are passed into lime water, or into water as it passes over limestone.

IMPORTANT developments in the technology of the industry have been indicated in the brief review already given of chemical and unit processes. Some of them have been the contribution of the industry itself. Many of them, however, have been borrowed from other industries. The mining industry, for example, has contributed sedimentation equipment, continuous suction filters, and the rod mill. Other industries have contributed the process for reburning lime sludge, the means for recovering the heat carried away from the pulp and paper dryers in the moisture laden air, and the method for preparation and control of rosin soap emulsions.

Sedimentation equipment has greatly reduced the loss of fiber to the sewer and has effected other economies already cited. Continuous suction filters have shared in the production of those economies and have also made possible a cleaner pulp with the consumption of less water. The ultimate results have been lower cost and better quality of bleached pulp and lower cost in evaporating the waste liquors preliminary to the recovery of chemicals.

The rod mill has been demonstrated as an efficient refiner of knots and screenings from chemical pulps and an effective beating engine for pulp. Its ability to refine partially cooked material has made possible the practical application of those semi-chemical processes which merely soften the fibrous material and depend upon mechanical means for a completion of the pulping. High yields of strong pulp have been thus obtained from coniferous wood as have high yields of a relatively white pulp from some of the deciduous woods.

The economical reburning of the lime sludge eliminates a troublesome waste. The recovery of heat from the paper machine dryers has effected marked steam economies. The perfection of the process of emulsifying rosin size has resulted in economy of size and improved the water resistance of the sized papers.

Within the industry itself intensive study of the chemistry of the sulphite process is now resulting in higher yields and improved quality of product. Sodium sulphite has been introduced into the caustic liquors of the soda process for the improvement of bleached pulps from broadleaf woods. Sodium sulphite has come to be a pulping agent on its own account. Modifications have been introduced in the processes for the production of bleached sulphite pulps which are resulting in products of high alpha cellulose content that are finding important practical applications. The sulphite process has been modified so as to facilitate the use of broadleaf woods for pulps which can supplement sulphite pulps from coniferous woods. Losses of ground wood pulp have been reduced through the application of chemical preservatives, and partially decayed wood is found to be not without value in the sulphite process.

It must be concluded, therefore, that the chemical engineer has an important field in the pulp and paper industry and that he has already made valuable contributions toward its progress. Each forward step unfolds new and often difficult problems to be solved but past successes give promise of ever increasing attainments in the future.

Less Familiar Aspects of **PLASTICS Industry**

By CARLETON ELLIS

*Ellis-Foster Company,
Montclair, N. J.*

THE FIELD of plastics extends over so wide a range that the limitations of this article proscribe any detailed discussion of raw materials employed in the industry. Binding agents which include dried blood, casein and algin on the one hand, through the natural resins to the synthetic resins, rubber and cellulose ester, on the other hand, call for a great variety of chemical raw materials in the production of commercial plastics.

This article will not endeavor to discuss the primary raw material requirements of products so well standardized as nitrocellulose and celluloid, nor of the synthetic resinoids of the Bakelite type. Attention will be directed particularly to certain of the more recent plastics and the chemical raw materials which they demand.

The needs of the nitrocellulose industry for sulphuric and nitric acids, for camphor, alcohol and various solvents, pigments and plasticizers are well known. A less familiar requirement of this industry is tricresyl phosphate, used as a plasticizing and inflammability-reducing agent for nitro-cellulose and cellulose acetate. The substance is prepared from cresol and phosphorus oxychloride. Chemical industry has had to supply phosphorus oxychloride in substantial quantities to meet the requirements of this market.

The construction of a large plant to manufacture synthetic phenol used in the manufacture of Bakelite is one of the recent developments looking towards the supply of raw materials for this type of synthetic resins. Providential, also, in a way, has been the development of synthetic methanol in Germany, and in this country; for this material constitutes the main source of formaldehyde, without which resins of the Bakelite type would not be cheaply available. Efforts are constantly being made to obtain formaldehyde at a still lower cost by the oxidation of methane of natural gas. This has been deemed of sufficient importance to call for investigations by the British Government through the Department of Scientific and Industrial Research (see *Chem. & Met.*, Vol. 34, No. 12, p. 731).

IN THE EARLY DAYS of the phenol-formaldehyde resins, there was available only a small supply of acetaldehyde. Resins made by condensing this aldehyde with phenol did not appear to have much commercial significance. The developments brought about by war conditions greatly stimulated the synthetic production of acetaldehyde from acetylene, until today this aldehyde is obtainable at so low a cost it promises to play an important part in the future of the phenol-aldehyde resins. Acrolein, furfural, butyl aldehyde, crotonaldehyde and various other aldehydes have become available in recent years, and are beginning to modify the development of certain plastic products.

Phenol and formaldehyde, reacted to form phenol alcohol, can be esterified with rosin to make a resinous substance of value in the manufacture of certain types of

varnishes. When incorporated with tung oil a varnish which is relatively quick-drying can be prepared.

THE so-called "synthetic glass" made from urea and formaldehyde has attracted a great deal of attention in this country, and abroad. Phenol-formaldehyde resins, and in fact most resins made from the condensation products of phenols and aldehydes present the difficulty of discoloration by light. A vast amount of work has been done in the search for a thoroughly commercial method of suppressing or eliminating these undesirable coloring agents. Hence the announcement of the glass-like urea-formaldehyde material was welcomed with great interest. Chemists on all sides began the study and adaptation of these condensation products. The synthetic glass was found to be relatively light-stable. The extent of use of the material is likely to be promoted by the recent reduction in the cost of urea. According to reports, synthetic methods developed in Germany have made it possible for urea to be placed on the market as a fertilizer and sold approximately on the usual basis of nitrogen unit content as employed in the fertilizer market. The lowered cost of urea and the reduction in the cost of formaldehyde due to synthetic methanol give promise of a considerable future for the urea resins.

The raw material requirements in the rubber industry are so extensive and in the main so well-known, that recital here is unnecessary. The vulcanization of rubber has, however, brought into commercial being a class of substances which only a few years ago would have been regarded as wholly foreign to rubber manufacturing processes. We refer to vulcanization accelerators, the number of which has now become legion. Most of these are highly complicated organic substances requiring precise chemical control in their production. It is reported by Geer that the increased turnover in the rubber factory, made possible because of these accelerating compounds, has saved the rubber industry fully two hundred million dollars in investment in buildings, presses, molds and power plants, which otherwise would have been needed to hold the present rubber goods output.

Chemical industry lately is being called upon by the rubber manufacturer to supply anti-oxidants, those organic substances which have the much desired effect of extending the life of rubber articles. These substances embrace a rather diversified class of bodies. Comparative artificial aging tests carried out at 55 deg. C. for periods up to 80 days have shown that the life of rubber is increased three- to five-fold by treating with hydroquinone. Formerly, a rubber tire which, on standing for a period of say two years, would deteriorate seriously will, when prepared with about one per cent

of antioxidant, become so stable a character that its shelf life will be increased to eight or ten years.

The cellulose acetate industry is still awaiting the discovery of a method which will enable cellulose to be directly acetylated by acetic acid. Improvements are being made constantly in the manufacture of acetic anhydride and certain new acetylating reagents are also enjoying a commercial try-out. The quality of cellulose acetate has been considerably improved in recent years and the demand for it has greatly increased. Not long ago the writer happened to be in the office of a physician who specializes in X-ray work and asked him if he were using nitrocellulose film. The physician replied that he formerly used nitrocellulose, but one day he awakened to a realization that he had in storage in the apartment house where his offices were located, probably between two and three tons of nitrocellulose film negatives, which he was keeping as records. A recognition of the hazard from the storage of so large a quantity of this inflammable material thereupon caused him to dispense with nitrocellulose and to turn to the cellulose acetate film. At that time the acetate film was being produced of a quality which rendered it much less satisfactory to use than nitrocellulose. Improvements which have been put into force of late years have eradicated most of these weaknesses and today cellulose acetate film is widely used in medical and dental X-ray work.

Still another field which has been invaded by plastics, or binding agents generally classed with the plastic substances, is the manufacture of so-called "non-splinterable" glass. This is made today by cementing a sheet of celluloid between two sheets of glass, various cementing agents being employed. Nitrocellulose decomposes on protracted exposure to light, and for that reason is not the most satisfactory reinforcing material to use in making non-splinterable glass. Gases generated may even rupture the "sandwich" and this has, in fact, been reported in a building where some of the duplex panes of glass with which the window frames were fitted have separated with a briskness all the more noticeable because of its unexpected occurrence.

Cellulose acetate promises better results in the production of "sandwich" glass, as it is not as easily discolored by light, and is more stable in other respects for this purpose. However, neither of these cellulose compounds are ideal for the intermediate layer, and investigators are seeking new plastic substances. One recently proposed is a hardened derivative of itaconic acid.

THE FIELD is being actively investigated with the hope that a substance may be found which can be cheaply produced and will serve to bind firmly together two sheets of glass to afford the non-splintering quality which nitrocellulose provides. At the present time the cost of such "sandwich" glass is so great that it is not used widely in automobiles, but if producible at a reasonable cost the market would be a very wide one as it should supersede ordinary plate glass in automobiles, and the consumption in this direction alone would be enormous. The aim now is to produce "sandwich" glass of a thickness, such that with the intermediate layer, it will not exceed the usual plate glass thickness of $\frac{1}{4}$ -in.

The commercial development of methods of making phthalic anhydride by the air-oxidation of naphthalene has given a stimulus to the manufacture of phthalic glyceride resins. These have been made on a small scale for a good many years and have found a very limited use in the manufacture of insulating materials. More re-

cently a form of phthalic glyceride resin has been employed in a somewhat larger way in the production of built-up mica sheets, made by cementing together mica flakes, with the employment of resin as a binder. Mica sheet is now prepared in large quantities by this method and quite elaborate machinery has been devised for laying the mica flake in place and spraying layer upon layer with a solution of the resin, until the requisite thickness of sheet has been obtained. After drying and baking, the sheet may be pressed to form rings, cups, cones and other insulating parts. Likewise, the sheets can be formed into tubes which are useful in special forms of insulating equipment.

DUE TO the introduction on the market and at reasonable cost, of ethylene glycol and of the glycol ether sometimes called "diethylene glycol," a still greater variety of resins of the organic-acid-polyhydric-alcohol type may be prepared. The glycols and glycol ethers, generally speaking, yield with organic acids, resins which are softer than those prepared in a similar manner from glycerol. In a number of cases the products obtained are more of the nature of synthetic balsams. The writer has prepared a great variety of these resins and balsams and has found them of interest in various plastic products.

Chemical industry likewise has brought into the market that substance of strange behavior—ethylene oxide—a compound so highly reactive that it resembles formaldehyde in combining avidity; though, of course, the products derived by its reactions are totally different structurally from those resulting from the use of formaldehyde. Organic oxides of higher molecular weight are likely to be forthcoming in the near future. From ethylene oxide may be prepared the body known as triethanolamine. A supply of this curious substance is promised in the near future. Triethanolamine combines the properties of an amine and a polyhydric alcohol and yields resinous bodies and balsams very readily in the presence of various organic acids.

The nitrocellulose lacquer industry is persistent in its demand for a synthetic resin which will blend nicely with nitrocellulose and assist in building up the film or coating. A lacquer enamel for general usage made only with nitrocellulose does not yield in one or two applications a coating of sufficient thickness. Natural resins such as rosin, kauri, and also rosin ester or ester gum, can be used with nitrocellulose in minor proportion. The presence of these resins tends to increase adhesion of the coating to the surface, while the thickness of coating or "fullness" increases as the content of resin is increased. Such natural resins, however, have the very pronounced and serious disadvantage of shortening the life of the coating. The greater the proportion of the resin the less the endurance on exposure. Recently a new type of synthetic resin has been put into commercial use, which blends perfectly with nitrocellulose and may be used in any proportion with the latter, so that coatings of substantial thickness can be easily produced. The synthetic resin of this type has a pronounced preservative effect on the nitrocellulose and outside exposures conducted under severe service conditions have shown beyond question remarkable enduring qualities.

It is beyond the province of this article to go into details concerning this new preservative type of synthetic resins. Suffice it to say that chemical industry will be drawn upon extensively to supply the raw materials used in the manufacture of these preservatives.

CERAMIC

and Chemical Engineering

By A. F. GREAVES-WALKER

*Professor of Ceramic Engineering,
North Carolina State College of
Agriculture and Engineering,
Raleigh, N. C.*

DURING the past 30 years or ever since the birth of ceramic engineering there has been a growing interdependence between the industries in the field covered and those in the field of chemical engineering, in fact it might truly be said that in many cases, they have become so closely allied and related as to make it extremely hard to draw any distinct line of demarcation in some of them. During the thirty years of its existence the field of ceramic engineering has been gradually extended until at the present time it covers those industries using non-metallic minerals as the principal raw materials and in which a process of firing is necessary in the manufacture of the products. In other words, thermo-chemical reactions or what F. J. Tone refers to as the "chemistry of high temperatures" form the basis of all ceramic processes.

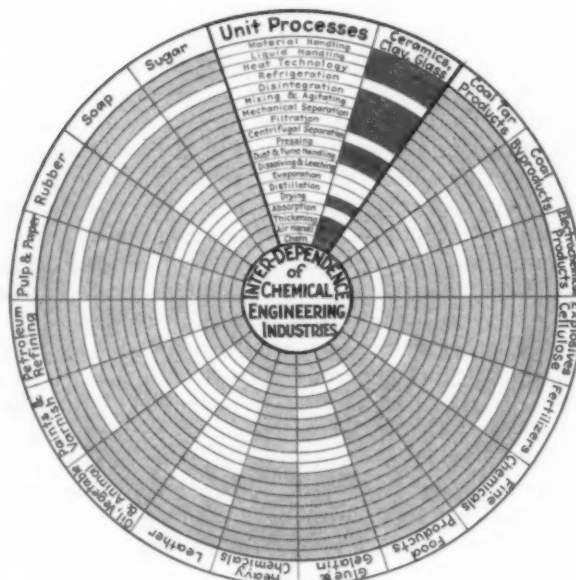
The industries in the ceramic engineering field are grouped under the following headings: structural clay products, white wares, stoneware, refractories, graphite products, glass, abrasives, enameled iron and steel, cements and heat insulating materials.

Ceramic engineering in its field has no doubt played its most important rôle in bringing about technical control of the thermo-chemical processes through the employment of technically trained men. These same men have also conducted researches which in many instances have placed our ceramic industries in advance of those of all other nations in their particular lines. Notable instances of this are the spark plug porcelain, electrical porcelain, high temperature refractories and abrasives industries. Colloid and physical chemistry, which have become so important in ceramic engineering, have naturally made the technical man with a good knowledge of chemistry and modern control methods a necessity, so much so in fact that few ceramic industries of importance do not now have at least a control laboratory, and in many instances a research laboratory.

The interdependence of the ceramic and chemical engineering fields can best be shown by pointing out some of the more important contacts, where the products of one become plant or raw material for the other; and where the chemist and chemical engineer enter the ceramist's field.

Under the structural clay products group are manufactured acid resisting brick, vitrified pipe, acid rings, acid resisting cements and a number of other products which are important items in chemical plant construction. In this group of industries but few products of the

Industries



chemical plants are used. In the sewer pipe industry considerable quantities of common salt are required for salt glazing, while in the terra cotta industry, oxides of lead, cobalt, manganese, copper, nickel and other metals are used to produce the colors in the glazes.

All of the industries in this group, being users of heavy machinery, are also large consumers of lubricating oils. Similarly, with the great increase in the number of tunnel kiln installations fuel oil consumption is increasing.

Under the white ware group are the various items classed as chemical porcelains, used principally in laboratories and familiar to every chemical engineer. Within the past decade American made porcelains have been improved to such an extent through research that they have surpassed in quality the European product which for so many years controlled our markets.

In this group also are the manufacturers of dinner ware, art ware, wall tile and other white ware products which are decorated in colors. The dinner ware group are large consumers of lead compounds and the borosilicates used in overglaze decoration. The art ware and wall tile group are large consumers of alkaline earth carbonates, lead compounds and the metallic oxides of cobalt, manganese, iron, uranium, nickel, and chromium as well as the chlorides and nitrates of the same metals and, in addition, gold.

In the manufacture of bone china, bone ash forms an important part of the batch, quantities up to 44 per cent of the body mixture being used.

The stoneware group is very important to certain branches of the chemical engineering field, with its stoneware stills, pumps, vats, and containers and the innumerable smaller shapes which go into plant construction.

It is only comparatively recently that all chemical stoneware used in the country was imported from Germany. American manufacturers, employing ceramic engineers with a knowledge of the requirements of the chemical industries, can now supply all requirements. It is probably safe to say that in no other ceramic industry is such careful technical control necessary as is required in this line. The control of shrinkage alone, so as to effect the perfect fitting of parts, is a problem approached only by that of the electrical porcelain industry.

THE refractories group is of course, all important. Many of the chemical processes are oxidation or electric furnace processes and in both, refractories properly designed to meet the required chemical reactions are necessary. For years the refractories manufacturer has been at work developing better pulp mill refractories for litharge and zinc oxides furnaces. Another problem on which much work has been done is the linings for furnaces in cane sugar mills burning bagasse. In this case the alkalis in the bagasse rapidly flux away the refractories. Co-operation between the chemical and ceramic engineers has solved these problems and many others, at least to a large extent.

In the glass group the ceramic and chemical engineers and chemists are each taking an important part. Practically all of the important research developments can be attributed to the work of chemists, although the ceramic engineer or technologist is constantly taking an increasingly active part.

Among the outstanding developments of the past few years is the perfecting of mechanical production of plate glass, a great contribution of Henry Ford, to the ceramic field. This development, the work of engineers, revolutionized the plate glass industry. Another outstanding achievement, the work of a ceramic engineer, A. V. Bleining, was the development of American optical glasses through intensive research during the war.

It was due to the work of a German chemist, Otto Schott, in studying the effect of light passing through glass containing various chemicals that gave the Europeans control of the world's optical glass market up to the time of the World War. The American manufacture grew to considerable proportions during the war, but since that time has almost ceased due to European competition.

Another important development brought about through the researches of the same German chemist is that of chemical glassware, with which every chemical engineer and chemist is familiar. The splendid development of this industry in the United States is due largely to the work of E. C. Sullivan of the Corning Glass Works, one of the world's outstanding glass chemists. Through increasing the silica and replacing the soda ash content of common glass with boracic acid, American chemical glassware is now made which is admittedly superior to any in the world. This work has also led to the development of glass cooking ware which has been instrumental in driving from the kitchen, to a large extent, the products of the enameled ware and kitchen pottery industries.

Practically all the advance in the manufacture of quartz glass, used extensively in the chemical industries, has been made in the United States; and while much of the improvement in manufacturing technique has been due

to the work of electrical engineers, the foundation was laid by ceramic engineers engaged in developing ware for the chemical industries. It has also been recently announced that glass chemists in this country have succeeded in producing a much less expensive glass having the same qualities as quartz glass.

Glass manufacturers are large users of the products of the chemical industries. The common bottle glasses carry a considerable percentage of soda ash, the window glasses a considerable percentage of salt cake and the cut glasses: lead oxides, pearl ash and sodium nitrate. In producing colored glasses selenium, cadmium sulphide, zinc oxide, gold and copper oxides are used for reds; manganese oxide for amethyst; silver or cadmium salts for canary yellow and copper or cobalt salts for blues. Etching is done with hydrofluoric acid and in the manufacture of mirrors ammonia, silver nitrate and formaldehyde are used.

Enameled iron and steel are finding an increasingly larger use in the chemical engineering field. At the present time this industry is carrying on a number of important research projects designed to develop better acid resisting enamels.

The enameled ware industries are large users of acid for pickling the iron and steel, and also tin oxide and zirconium oxide, as well as the metallic oxides used in producing color enamels.

In the abrasives industry the electro-chemist or the electro-chemical engineer and the ceramic engineer have joined hands. Silicon carbide, the first artificial abrasive, was originally produced by Acheson in 1891. Some idea of the development of the industry can be gained by contrasting the first silicon carbide furnace with its capacity of one-quarter-pound per day with the present furnace with a capacity of 10,000 pounds. Out of the development of silicon carbide has come the carbon electrode and the artificial corundum industries.

Common salt is one of the ingredients in the carborundum batch, and in the purification treatment, quantities of sulphuric acid and caustic soda are used. Many of the bonds used in the production of grinding wheels are products of the chemical industries. Besides clays, wheels are bonded with silicate of soda, shellac, rubber and natural and synthetic resins.

THE PORTLAND CEMENT industry, although included in the ceramic engineering field, has been left almost entirely to the chemist and chemical engineer. First made by an engineer, John Smeaton, in 1756, it has remained for the American chemist to improve and perfect it. Of all the ceramic industries, it no doubt requires the closest control of the chemical composition of both raw materials and finished product. Recently new rapid setting cements have been placed on the market which give promise of replacing much of the standard Portland cement.

In a number of cements, products of chemical industries are important ingredients. This is especially true of the oxychloride cements, in which magnesium and zinc chloride are used, litharge cement in which glycerine is used and dental cements into which a number of chemicals enter. In another class, those known as refractory cements, much sodium silicate is used.

There are numerous other branches of the ceramic industries in which there are close contacts and relationships with certain branches of the chemical industries but those pointed out above are sufficient to show the increasing interdependence between the two groups.

COAL PROCESSING

Exemplifies Unit Operations

By F. W. SPERR, JR. and J. F. BYRNE

*The Koppers Company,
Pittsburgh, Pa.*

THE MODERN COKE PLANT with its ovens of ingenious and highly specialized design, its elaborate machinery for coal preparation, and coke handling and its highly organized equipment for the recovery of by-products is the product of a special profession, in the evolution of which the civil, the mechanical, the electrical and the chemical engineer have all contributed. This article will deal with such phases of the industry as are of direct interest to the readers of *Chem. & Met.*, but with no thought of arrogating to the chemical engineer the results of a splendid technical co-operation.

The following tabulation indicates the relationship between the more common unit processes and coke plant practice:

I—Material Handling

(a) Solid

1. Coal for ovens—lump and pulverized
2. Coke—hot and quenched
3. Producer fuel
4. Boiler fuel
5. Ammonium sulphate
6. Oxide for dry purification of gases
7. Sulphur from liquid purification process

(b) Liquids

1. Ammonia Liquor
2. Tar
3. Oil for light oil scrubbing
4. Oil for naphthalene removal
5. Solutions for liquid purification plant
6. Waste liquids—still waste, etc.
7. Water for cooling coils, boilers, coke quenching,

(c) Gases

1. Producer gas for underfiring ovens
2. Gas from coal distillation
3. Air for combustion of producer gas
4. Air for actification of liquid purification solutions
5. Steam for exhausters, distillation of ammonia, light oil, etc.

II—Crushing, grinding, screening

- (a) Preparation of coal for ovens
- (b) Sizing of coke for markets

III—Vaporization and distillation

- (a) Steam production in boiler plant and producer waste heat boilers
- (b) Carbonization of coal—a distillation process
- (c) Recovery of ammonia from liquor
- (d) Distillation of light oil from wash oil

IV—Filtration

- (a) Recovery of ammonium sulphate from saturator bath
- (b) Sulphur recovery from liquid purification plant

V—Condensing and scrubbing

- (a) Complete removal of tar and condensation of water from coal gas
- (b) Scrubbing producer gas
- (c) Condensing vapors from light oil stills

VI—Precipitation

- (a) Ammonium sulphate recovery in saturator with sulphuric acid
- (b) Sulphur precipitation in liquid purification plant

VII—Settling

- (a) Separation of tar and ammonia liquor
- (b) Clarification of plant waste

VIII—Absorption

- (a) Removal of ammonia from coal gas by water scrubbing
- (b) Absorption of naphthalene by gas oil
- (c) Scrubbing light oils from gas by wash oil

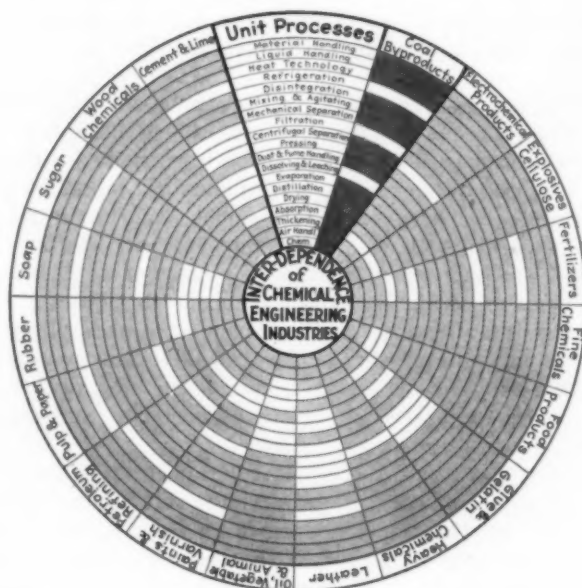
IX—Combustion and heat transfer

- (a) Combustion of gas for oven heating
- (b) Heat transfer
 1. In coke ovens
 2. In condensers and coolers
 3. In producer waste heat boilers
 4. In ammonia stills
 5. In light oil stills

To discuss in detail each application of the various processes is beyond the scope of this paper. However, a brief review of the operations in the by-product coking plant will illustrate the close relationship between chemical engineering and the entire coking process.

In the converting of a ton of raw coal into coke, gas, tar and other byproducts, it is necessary to handle, in addition to the coal itself, 1,400 lb. of coke; 11,000 to 12,000 cu.ft. of finished gas; 10 to 12 gal. of tar; 3 to 6 lb. of sulphur from the liquid purification plant; 16,000 to 18,000 cu.ft. of producer gas for heating the coke ovens; the air necessary for its combustion and the resulting stack gases; various amounts of ammonia liquor, depending on the condensing system used; gas oil for naphthalene scrubbing or wash oil for benzol recovery; 600 gal. of water for coke quenching in addition to that for condensers, coolers and miscellaneous uses; and boiler feed water and steam for exhausters, stills and for heating purposes.

Coal and coke.—The great bulk of solid materials handled consists of coal and coke. The technique of



coal and coke handling in this industry has been developed to a high degree of efficiency. The handling system receives coal of various sizes from railroad cars, barges, or storage yards, elevates it to pulverizing equipment, provides facilities for mixing the various coals in the required accurate proportions, and delivers the pulverized mixed coal to the storage bins above the coke ovens. From these bins, the coal is delivered by gravity to the charging larry, a traveling car equipped with hoppers from which the coal is dumped into the ovens.

Belt conveyors are the most satisfactory means of transporting coal through the system. Where large capacities are required, sloping belts are more economical than bucket elevators.

The equipment should be designed so as to minimize the amount of dust in the air of the buildings since such dust is extremely explosive. In the case of a very dusty coal, water may be sprinkled on the belt. This must be done judiciously, however, as excess moisture decreases the capacity of the plant and increases the heat required to carbonize the coal.

LONG drops or other conditions that would tend to segregate the coal of the mixture or to concentrate the ash in any part must be avoided. The system must be reliable, that the ovens will never be without coal. It must be flexible, that the proper coals can be thoroughly mixed in the proper proportions and delivered to the proper bins. Automatic shut-down devices are essential, so that a stoppage in any part of the system will stop all the preceding belts.

Coke handling is a problem unique to the coke industry, because of (1) the high temperature at which the product is discharged from the ovens; (2) the abrasive character of coke; and (3) the necessity of avoiding undue shattering in handling.

The coke is pushed from the oven at a temperature of about 1,700 deg. F., into a "quenching car," in which the coke is cooled by a liberal shower of water. The bottom of the quenching car slopes from the oven side toward movable gates, which permit the quenched coke to discharge by gravity onto the wharf. The latter is a sloping metal platform with gates at its lower side. When the coke has cooled further and excess moisture has evaporated, the wharf gates are opened, discharging the coke over a rotary feed to the wharf belt. The wharf belt elevates the coke to the screening station where it is sized according to the use for which it is intended.

The larger sizes of coke are separated on rotating grizzlies, and the finer sizes on shaker or on vibrating screens. The screens may discharge directly to railroad cars over a boom conveyor, or may feed to belts connecting with storage bins, with the producer plant, or with the boiler house. The arrangements of any plant will vary according to the facilities for coke disposal and the sizes in demand.

In the design of coke handling equipment, the necessity of avoiding long drops must be emphasized. Even the best coke is somewhat brittle and consequently a uniform and satisfactory product cannot be delivered unless reasonable precautions in handling are observed. As with all equipment in a continuous plant, the coke handling system must be absolutely reliable. Shut-downs of even an hour in the conveyor system from the wharf may cause accumulation of coke and delayed pushing of ovens. This means reduced capacity, and if the delay is prolonged, the whole operation of the

plant is upset. In plants in which it is necessary to adhere to a rapid pushing schedule, extra pushers and quenching cars are provided for emergencies, but the conveyor system must operate practically without stop.

THE DETAILS of the arrangement of the coal and coke handling system will vary in different plants depending upon the available ground space, arrangement of buildings, shipping facilities, etc. The two factors of most importance are reliability and flexibility, followed closely by economy of operation and maintenance.

Gaseous and volatile products.—Gas and liquor can best be considered together since the foul gas leaving the oven is composed of fixed gases, which constitute the final "coal gas," together with vapors or suspensions of tar, water, light oils, ammonia and particles of coal dust. The final or fixed gas constitutes about 50 per cent by weight of the volatile products leaving the oven.

Condensation begins as soon as the products leave the oven, and is assisted by the spraying of weak ammonia liquor into the collecting main or suction main. Nearly two-thirds of the tar and a large amount of the water vapor are removed before the gas reaches the primary coolers. In the latter, the gas is cooled from about 175 deg. F. to 75–85 deg. F. Since the sensible heat of the gas itself is considerably less than the latent heat of the condensable vapors, the saturation temperature of the gas with respect to the various condensable ingredients must be known and allowance made for the latent heat evolved through the temperature range of the cooler. The well designed cooler must give efficient heat transfer from the gas to the cooling water. It must provide baffling for the removal of tar and dust particles and must not offer too great resistance.

After leaving the primary coolers, the gas enters the exhauster. Here it is compressed to 70 to 80 in. of water, sufficient to force it through the remainder of the system to the holder. The two types of exhausters in common use are the low speed positive type, such as the Roots or Connorsville, and the high speed turbo-blower type. In addition to compressing the gas, the exhausters, especially the centrifugal type, remove 50 to 75 per cent of the tar remaining after the coolers.

IN SOME plants the heat of compression is removed by a secondary cooler following the exhauster, but in most cases, the gas passes directly to the tar extractor. The purpose of the tar extractor is to remove the fine tar mist from the gas. In the most common type, the Pelouze and Audouin, or "P and A," the gas passes through perforations in an inverted drum or bell, against a similar outer bell, whose perforations are staggered with respect to those of the first. The finely divided gas streams, with tar in suspension, impinge on solid surfaces, causing the tar particles to coagulate. The efficiency of the extractor depends upon the gas temperature and upon the pressure differential.

The gas leaving the tar extractor is practically free from tar. It carries about 75 per cent of the ammonia and practically all of the original light oil content. Next, it passes through an indirect steam reheater which increases its temperature to 130–140 deg. F., the optimum temperature for the inlet to the saturator which follows. The saturator is a lead-lined, covered vessel containing a bath of 60 deg. Bé, sulphuric acid, under the surface of which dips the "cracker pipe." The gas, in flowing through this pipe, makes intimate contact with the acid

and the ammonia is removed as ammonium sulphate. The sulphate is removed from the saturator by an ejector operated by compressed air. The solution flows to a drain table from which the mother liquor is returned to the saturator. The accumulated sulphate is transferred in batches to centrifugal driers, which deliver the ordinary commercial product containing 25 per cent NH_3 . The production of absolutely dry sulphate requires further treatment in an air drier.

Meanwhile, the tar and some ammonia liquor have been condensed from the gas throughout the system from the ovens to the tar extractor. These are run to separating tanks, that condensing before the primary cooler to one tank, and that from the remainder of the system to another. The tar separates out by gravity and is run to tar storage tanks for shipment. Practically no coke plants refine their tar. It is sold to tar refineries or, if the ovens are in connection with a steel plant, the tar is frequently used as fuel in open hearth furnaces.

The ammonia liquor is used for spraying the mains before the primary coolers to facilitate cooling of the gas and the precipitation of the tar. Part of the condensed liquor is run from the tar separating tanks to the ammonia still. This is essentially a column composed of superimposed sections somewhat similar to a bell washer. It is arranged in two parts, the upper or volatile still and the lower or fixed still. The liquor flows down from one section to another, and as it descends it is heated by an upward flow of steam and vapors. Reaching the bottom of the free still, the liquor flows into the fixed still, where it is mixed with milk of lime to decompose the fixed ammonia (chlorides, sulphocyanides, and so on). Steam is added at the bottom both of the free and the fixed stills.

The ammonia and steam pass through a dephlegmator and then to absorbers or to separate saturators, depending on whether ammonia liquor or sulphate is desired. One system adds the vapors from the still to the gas stream immediately before the main saturators, where they assist in controlling humidity and temperature.

RETURNING to the gas itself, it leaves the saturator through an acid separator, at 130–140 deg. F. and is cooled to 70–80 deg. F. in a final direct type cooler. Here considerable moisture is condensed and also some naphthalene. The final cooler is generally a tower filled with wooden hurdles arranged to give intimate contact between the water and gas with minimum resistance.

Where the gas is to be used for city distribution, the light oil is not removed but is left in the gas to increase its heating value. In this case, a naphthalene scrubber is frequently used to reduce the naphthalene in the gas to a concentration at which none will be deposited at the lowest temperature reached in the distribution system. One type of naphthalene scrubber, the Koppers, consists of a two-section tower, (1) the primary or recirculating section in which oil is recirculated at a high rate and (2) the secondary or fresh oil section into which intermittent "shots" of fresh oil are charged. In the primary section, the vapor pressure of naphthalene in the gas is reduced to such a point that the remainder can be reduced by very small amounts of fresh oil. Because of the small amount of fresh oil used, the absorption of light oil from the gas is very small and consequently the reduction in heating value is practically nil.

Where the coal gas is used in a steel plant the light

oils are generally scrubbed from the gas immediately after the final cooler. The light oil absorbers are towers filled with wooden hurdles over which an absorbent oil flows. This wash oil absorbs 2 to 3 per cent of its weight of light oil from the gas. As in the naphthalene scrubber, the light oil scrubber must give the maximum contact between the wash oil and gas. With counter-current flow as is generally used, with sufficient time of contact and with proper cooling of gas and of oil, 90 to 95 per cent of the light oil vapors can be removed.

THE LIGHT OIL is recovered from the wash oil by distillation with direct steam. After cooling in heat exchangers and cooling coils, the wash oil is recirculated in the scrubbers. The crude light oil is redistilled in intermittent stills equipped with fractionating columns, and washed with strong sulphuric acid and caustic to remove the unsaturated compounds which cause discoloration and gum formation. The washed light oils may be redistilled further if pure products are desired. Light oil recovery and refining requires extremely fine balances of temperatures and oil rates for the maximum recovery of the best products, and well designed heat exchangers, stills and coolers to make the entire process economical.

Purification of gas.—After the naphthalene scrubber or light oil plant, the gas passes through one more treatment before it is ready for distribution—namely, purification for hydrogen sulphide removal. This may be done either in the dry or oxide process or in the liquid process. In the former, the gas passes through layers of hydrated iron oxide mixed with wood shavings. The hydrogen sulphide reacts with the oxide, which may be revived by air either in the boxes or outside.

Liquid purification is now practiced in a large number of plants. These processes may be classified as non-recovery processes and sulphur recovery processes. In the Seaboard non-recovery process, the gas is scrubbed with a dilute solution of sodium carbonate which removes most of the hydrogen sulphide and hydrocyanic acid while these impurities are in turn removed from the solution by aeration. The air containing the impurities in a highly dilute form may be burned or otherwise disposed of. In the sulphur recovery processes there are added to the circulating solution, agents which make possible the oxidation of the hydrogen sulphide to free sulphur. This is separated from the solution by flotation in the form of a foam which, notwithstanding the extraordinary fineness of the sulphur particles, is readily amenable to filtration.

The heating of the coke ovens is an excellent illustration of the scientific application of the principles of combustion and heat transfer. Heat is applied to the oven walls at such a rate that the coking process is completed simultaneously throughout the charge from floor to roof. This is accomplished by burning gas, preheated or not depending on the gas, with preheated air which passes in flues up over the silica brick ovens and down the far side, whence the burned gases go to heat the brickwork of the regenerators, and then discharge to the stack.

This general review of coke plant practice illustrates the variety of processes involved. It is through the recognition of scientific principles that the manufacture of coke has thus evolved from the fast disappearing bee-hive plant to the modern and efficient byproduct recovery system.

Inter-Relations of **PAINT, VARNISH** *and LACQUER Industries* *with Chemical Engineering*

By HARRY McCORMACK

*Professor of Chemical Engineering,
Armour Institute of Technology,
Chicago, Ill.*

IN THE FIELD of protective coatings, we have to deal not only with those of a non-metallic nature which are applied by brushing or spraying, but also with those metallic coatings deposited by electro-plating and by other means, as well as those which are the result of chemical changes in the surface to be protected. The present article is limited to the first classification and considers the most important materials in this group, paints, varnishes and lacquers. In general, we find that the industries which produce these coating materials are very large users of the products of chemical manufacturers as their own raw materials, and that these constitute a very considerable variety of chemicals. When one considers that the manufacturers of fine chemicals, heavy chemicals, wood chemicals and coal by-products all contribute to paint, varnish and lacquer industry,—that the producers of electrochemicals supply sodium hydroxide and chlorine, that certain of the products of petroleum refining are used, and that cellulosic materials are the basis of the lacquer industry, this claim for volume and variety is amply borne out.

In addition to this close linkage with the chemical engineering industries on the basis of materials, the unit operations ordinarily classed as chemical engineering play an important part in the manufacture of protective coatings. In fact, it will develop that with the exception of refrigeration, practically every operation of this type is represented at some stage in the production. It will, however, appear that there is still much room for improvement in the adaptation of the unit processes in many departments of these industries.

In showing the inter-relations which exist between chemical engineering and chemicals, on the one hand, and the paint, varnish and lacquer industry on the other, it will, perhaps, first be well to enumerate the materials consumed in the production of these products, in more detail than has been outlined before, and with specific reference to the consuming branch of the industry. Following that, we will examine the actual occurrence of the unit operations in the manufacturing processes of the component parts of the industry.

We find used in the production of the various paints: linseed oil and some linseed oil substitutes such as tung oil and soya bean oil; turpentine and turpentine substitutes; white lead, zinc oxide, lithopone; various coloring materials chiefly of inorganic origin such as red lead, carbon black, Prussian blue, chrome yellow, chrome green; and finally benzol.

We find used in the manufacture of varnish: linseed oil and linseed oil substitutes, turpentine and turpentine

substitutes, varnish gums both natural and synthetic, ester gums, benzol, methanol and ethyl alcohol. The pigmented varnish or enamels, contain in addition, pigment materials similar to those mentioned in connection with paints.

The lacquers contain nitrocellulose; varnish gums, natural and synthetic; ester gums; and solvents such as ethyl acetate, ethyl propionate, ethyl butyrate, ethyl alcohol, butyl alcohol, butyl acetate, toluol and naphtha. While no lacquer is likely to contain all of these solvents, it will probably contain several of them.

The lacquers will contain as plasticizers: dibutyl phthalate, diethyl phthalate, dibutyl tartrate, diethyl tartrate, diamyl phthalate, tricresyl phosphate and triphenyl phosphate. Similarly, although no one lacquer will contain all of these plasticizers, it may contain several and in different lacquers all of them will be found.

The pigmented lacquers will contain, in addition, similar pigment materials to those previously mentioned.

Passing now to a survey of the spread of unit operations in paint, varnish and lacquer production, we will see first the important place that material and liquid handling equipment has made for itself. These industries handle material in considerable quantity and of comparatively high specific gravity. It is consequently quite essential for economical operations to have as much mechanical handling of materials as is possible and reduce manual handling to the minimum.

A considerable volume of solids in suspension in water, as well as solutions of various materials in organic solvents, are pumped within each of these manufacturing establishments.

Heat technology, or combustion and heat transfer, are used in the processing of a number of the intermediate, as well as final products, of this industry. The lead used in the manufacture of white lead has either to be melted and cast, or melted and atomized. The zinc oxide is made by volatilizing the zinc itself in a furnace or by treating the zinc ore in a reduction-oxidation furnace. The barium sulphide used in making lithopone is produced by the reduction of barium sulphate and the zinc sulphide-barium sulphate mixture must be calcined in a furnace before a lithopone of the proper physical characteristics is obtained.

Boiled oil for paints is a familiar application of heating processes, while one of the major steps in varnish, and consequently in enamel manufacture, is the heat treatment and heat-bodding of the oil-gum mixture.

Disintegration is used in breaking up the agglomeration of particles formed both in the Dutch and the Carter processes for making white lead. The zinc ores are crushed and pulverized before being used for the production of zinc oxide. The calcined lithopone is crushed and pulverized prior to use. All of the inorganic pigments are ground with oil prior to being used either in paint or varnish. The cotton used in making nitrocellulose is disintegrated prior to and after nitration.

MIXING and kneading machines are used in preparing the nitrocellulose solutions for lacquer. Agitation is used in bringing about the reaction between zinc sulphate and barium sulphide to produce lithopone. White lead, made either by the Dutch process or the Carter process, is agitated in water to wash out soluble impurities, while agitation is also resorted to during the screening and classification processes applied to white lead in order to separate the too large particles from those of proper size. Mechanical separation by means of air flotation is used extensively in preparing inorganic pigments of proper particle size for paints, varnishes and lacquers.

Filtration is used to separate the zinc sulphide-barium sulphate precipitate from the mother liquor in which it is formed as a part of the process in making lithopone. Filtration is also used to separate many of the inorganic pigments and the organic lakes from the solutions in which they are precipitated. Clear varnish and clear lacquer are filtered to remove insoluble impurities which may be present and which would reduce the quality of the product. Centrifugal separation is replacing to some extent filtration in the production of clear varnishes and clear lacquer.

Hydraulic presses are used in the drying of the nitrocellulose, first to expel as much water as is possible, and then to hold the nitrocellulose in compact blocks while the balance of the water is displaced by alcohol.

Dust and fume handling equipment is employed for the recovery of zinc oxide from the combustion gases of the furnaces in which it is produced. This equipment is also used in connection with the furnaces producing red lead and litharge.

DISSOLVING and leaching operations are practiced in the preparation of lithopone and also in many of the colored pigments and lacquers.

Evaporation is used in reconcentrating the sulphuric acid after nitration of cotton. It is used in recovering the sodium hydroxide from the cotton cook liquors and in the concentration of some of the solutions used in precipitating inorganic pigments and organic lakes.

Distillation is used very extensively in the preparation of solvents for varnishes and lacquers and for the production of paint thinners. The distillation equipment used for the production of ethyl and methyl alcohols, ethyl acetate, toluol, xylol and naphtha is probably the most extensive and complicated distillation equipment we find used for any purposes. We also find extensive distillation equipment for the production of turpentine, ethyl butyrate, butyl alcohol and butyl acetate.

All of the white lead produced, regardless of the process, is wet when the manufacturing is completed so that the material must be dried before it can be used. This is also true of lithopone and of many of the inor-

ganic pigments such as Prussian blue, chrome yellow and chrome green. It is likewise true also of the lakes which are used as coloring materials in this industry. Practically all of these materials are produced wet.

Thickening operations are used extensively in the production of white lead both by the Dutch and the Carter processes; in the production of lithopone and in the manufacture of some of the colored pigments.

Carbon dioxide in rather large quantities has to be handled in the Carter process for making white lead so that gas and air handling equipment are used to a considerable extent in white lead plants. Similarly, other branches of the industry have their air and gas handling problems. For example, combustion gases, carrying zinc oxide have to be transported, cooled, settled and passed through a bag house.

We find in the production of the protective coatings many processes which we consider as of a strictly chemical nature. For example, there is fermentation, which is used very extensively in the preparation of many of the varnish and lacquer solvents, as for example, ethyl, butyl and amyl alcohols. Another widely employed operation is that of bleaching which is used in the preparation of cellulose for nitrating. Some of the varnish gums are likewise bleached prior to their use, either in varnish or in lacquers.

ELECTROLYSIS is playing an important part, since several of its products are used in the preparation of various materials for use in the paint and varnish industry. Among these are chlorine and sodium hydroxide which serve in the production of certain raw materials. White lead, itself, is being made in increasing quantity by means of electrolysis.

The brief summary which has been given showing the employment of practically all of the unit operations of chemical engineering at some place in the production of the various materials used in making paints, varnishes and lacquers or used in the process of applying these materials, brings out very definitely the fact that improvement in almost any of these processes means a cheaper manufacturing cost or a more satisfactory product.

The development of more satisfactory methods of crushing, grinding, pulverizing and air classifying mean the production of a more satisfactory pigment and a lower cost of manufacture, because the particle size will depend on this part of the treatment.

A new method of filtration coupled with a drying operation makes possible the elimination of some of the ancient methods used in the white lead and lithopone industry for the separation of these materials from water solution and for the drying of the final product.

The development of more satisfactory methods of centrifugal separation has meant the more satisfactory clarification of clear varnishes and clear lacquers, and at a reduced cost.

The development of new types of settling and thickening equipment means the cheaper production of white lead, no matter by what process it may be produced, and such equipment also assists materially in reducing the cost of many of the inorganic pigments and organic lakes.

The development of new chemical processes, within very recent times, has given us new sources of butyl alcohol, one of the important solvents of the lacquer industry. At the same time the development of new processes for producing methanol has made available larger quantities of this solvent at a lower price and of more satisfactory quality.

Improvement in fermentation processes has meant higher yields of butyl and propyl alcohols from the same amount of raw materials and has, therefore, increased the quantity of these products available and lowered their cost. A recently announced process promises to supply an unlimited quantity of lacquer solvents by oxidation of the petroleum distillates.

These illustrations point rather clearly to the close dependence of the paint, varnish and lacquer industries upon improvements in chemical engineering equipment as well as in chemical engineering processes. However, the paint and varnish industries in the past have been rather slow to change from the long tried and accepted methods of manufacture. The baby of the industry, pyroxylin lacquer manufacture, has been the only field in which chemical engineering practice has been accepted wholeheartedly.

Varnish making, on the other hand, to which but small application of the principles of the unit operations has been made, has been losing ground to lacquer. Perhaps varnish would be on a better basis to compete with lacquer were it to utilize more fully the knowledge we now possess of chemical engineering.

As the newest covering material, lacquer, has shown the most progressive spirit, so the most recently developed of the pigments, lithopone, shows most strongly the influence of chemical engineering practice. In each case the total lack of traditional procedure has probably mitigated in favor of the newer product.

The mixing of paint, again a time-honored and tradition-bound operation, is far down the scale of possible adaptation of the modern principles. It is the author's opinion that here is a place where much can be done to improve the quality and decrease the cost of paint.

It is, many times, impossible to predict the direction from which will come the impetus for an improvement in any product or process. As for example, the development of the violet ray light has placed in the hands of the paint technologist a satisfactory instrument for determining, in a short period of time, how well his products will withstand exposure over extended periods of time.

One physicist has contributed very largely to the fund of information we possess as to satisfactory methods for measuring particle sizes. Those connected with the protective coatings industry know that particle size is a matter of extreme importance in the preparation of a satisfactory product in many of their lines, particularly the paints and pigments, lakes and enamels. Another physicist has applied plasticity measurements to paints as a means of predicting their covering capacity. Still another investigates the hiding power of white pigments and paints and supplies much of the authentic data we have on this subject.

The modern lacquer industry originated when it was discovered that by a change in conditions of nitrating

cotton or by changing the conditions of cooking the cotton prior to nitration, nitrocellulose could be obtained which could be dissolved in the customary solvents, giving a solution of much greater concentration and much lower viscosity than could be obtained with the earlier type of nitrocellulose. These earlier types, when dissolved to such viscosity as would permit spraying, had a concentration of only 3 or 4 per cent of nitrocellulose, so that in order to make a lacquer with any "body," the

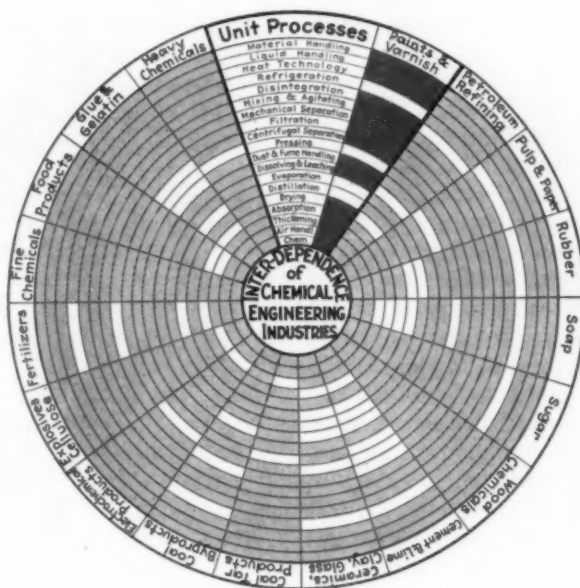
addition of large quantities of gums or resins was required. This procedure gave a protective coating with many defects. On the other hand, the nitrocellulose used today can be dissolved up to 35 or 40 per cent nitrocellulose solids and yet be of low enough viscosity to permit spraying. This makes possible a higher per cent of solids in the lacquer without the necessity of adding undue quantities of gums or resins.

The development of processes by which high boiling solvents are obtained in considerable quantity and at a market price which is not prohibitive, has led to the rapid development of satisfactory brush lacquers.

The combination of solvents used in the production of a satisfactory lacquer must meet the following requirements: The rate of evaporation must be such as to give a satisfactorily hard film in a period of time measured in a few hours; the solvents must evaporate in such ratio as to keep all of the solids in solution during the solvent evaporation; the drop in temperature due to solvent evaporation must not be marked enough to bring about moisture precipitation on the article being lacquered. This combination of solvents can, therefore, only be brought about intelligently by one thoroughly familiar with the fundamental conceptions of physical chemistry.

The development of satisfactory lacquers, at a satisfactory market price, has brought about the rapid replacement of varnish by lacquer so that the former manufacturer has felt that he, to obtain any business, must likewise go into the manufacture of lacquer. Many of the varnish manufacturers have lacked the necessary technical training themselves and have not had at their service laboratories with a proper technical staff to supply the necessary information for satisfactory lacquer compounding. This has led to much poor lacquer being placed on the market and has to some extent, handicapped the development of the lacquer industry.

It is the author's opinion that satisfactory paints and lacquers at a reasonable price are being made today, and can be made only by those companies having a technical staff thoroughly familiar with the chemical and physical properties of the materials being used, as well as a staff which is thoroughly familiar with all of the unit operations of chemical engineering which may be utilized in the manufacture of their products. In the varnish industry, however, the processes used and the products obtained are yet mainly empirical.



FERTILIZER *Industry*

Keeps Step with Development

of Chemical Engineering

By WILLIAM H. WAGGAMAN

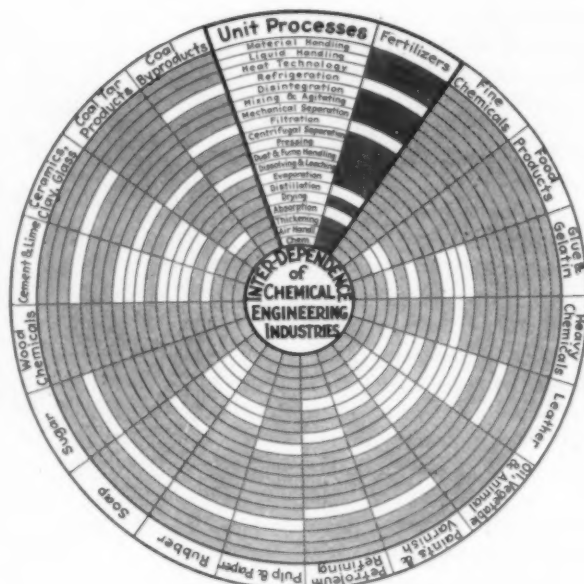
G. Ober & Sons Company,
Baltimore, Md.

FOR MANY YEARS our enormous natural resources permitted the development of certain fundamental industries on an extensive scale without the aid of chemical engineering or chemical processing. Probably the outstanding industries of this type are the fuel industry, those dealing with the production of structural materials and the fertilizer industry.

Not until the conception of the by-product coke oven, the city gas plant and the necessity of refining and cracking petroleum, did chemical engineering play an important part in fuel production. Only after cement, steel, tile and insulating materials began to be used in construction work did chemistry take its rightful place in these industries. It was not until the middle of the last century, when Leibig proposed the treatment of natural phosphates with sulphuric acid, that the fertilizer manufacturer employed any processes in his business except those of grinding, mixing and screening; nor did he market any products other than those derived from unrefined natural materials such as guano, crude potash salts, nitrates and organic wastes of animal and vegetable origin.

The manufacture of acid phosphate marks the beginning of chemically processed fertilizers, but it must be admitted that for many years after the introduction of this product the chemical engineer played a very minor rôle in the production of fertilizers. When, however, the high grade natural guano deposits became depleted, when certain organic ammoniates began to be withdrawn from the fertilizer market and used as stock feed, when it was realized that without adequate supplies of fertilizers and nitrogenous compounds for explosives a nation was at the mercy of a well equipped enemy, when war actually came and imports of potash and nitrates were either cut off or seriously curtailed, then, and only then, did the fertilizer industry fully realize its dependence on the chemical engineer.

ALTHOUGH sulphuric acid is the leading product of the heavy chemical industry it is so intimately related to the manufacture of fertilizers that it must also be regarded as a part of the fertilizer industry. Unquestionably the chemical engineering industries owe much to the fertilizer manufacturer for the development of the chamber process, for not only does the fertilizer business demand an immense tonnage of acid, but it must have it at a low price. These requirements stimulated the study of this process and brought it up to an efficiency where sulphuric acid has become the most widely used and one of the cheapest chemical reagents in the world.



Acid phosphate and double superphosphate are the chief fertilizer products manufactured by the large fertilizer companies, and the former has been the basis of practically all mixed fertilizers for many years. Because of the apparent simplicity of the acid phosphate process and the cheapness of the raw materials employed, the manufacture of this commodity has not been given the study which it deserves and which keen competition is now making essential.

The mechanical equipment used in the manufacture of acid phosphate, however, has kept pace with changing conditions. The importance of fine grinding, brought forth the air separator in connection with phosphate rock mills, and there are indications that further changes will be introduced to take care of certain grades of this mineral from Florida and Northern Africa. Mixing machinery has also been developed to a high degree of efficiency and the most up-to-date labor saving devices for handling heavy tonnages are employed in nearly every large fertilizer factory.

The general process of making acid phosphate consists in intimately mixing an average grade of phosphate rock (containing 31 per cent P_2O_5) with ordinary chamber sulphuric acid (52 deg. Bé. or 65 per cent H_2SO_4), the average acid-rock ratio employed being 95 to 100. The mixture is then run into a den, or partially closed chamber, and allowed to react and set for 18 to 24 hours, after which it is removed, milled, screened and stored. It is then either sacked and sold as a straight phosphate fertilizer, or mixed with potash salts and nitrogen carriers to produce complete fertilizers.

This is what the casual observer sees when he visits a fertilizer factory. To him the process appears so simple that he is apt to wonder why the product cannot be sold

at an even lower price than that prevailing today. But this is only part of the story, and it is the details of the process which run up the cost of the product and which present economic problems well worthy of painstaking research.

THE TWO main aims in the manufacture of acid phosphate are: To render the P_2O_5 present practically all water-soluble or available according to a conventional laboratory test, and to obtain a product which is in such mechanical condition that it will flow freely through the fertilizer drills. These aims are never fully realized without considerable expense in rehandling, storing and remilling of the product and even under the best conditions the time required, the loss of material involved and the wear and tear on the mechanical equipment are very serious.

When a den of acid phosphate is opened the material is in a damp spongy mass which is either cut out by mechanical excavators or removed by hand labor. In either case, it is usually milled, screened and stored for several weeks or months in order that the final reactions will be completed before it is sacked and sent to the consumer. The handling of this damp corrosive material is very costly for not only does it attack metal parts, but cakes wherever it is submitted to pressure. It corrodes and builds up in the crane buckets; it clogs the screens and mills; accumulates on pulleys, cutting the conveyor belts; it fills up the chains of elevators and causes excessive power consumption and loss of time and money through heavy repairs.

When stored or cured, acid phosphate again "sets up," due to the crystallization of gypsum and the phosphate salts, necessitating further breaking up, remilling and screening to obtain a product of the desired physical properties for ready distribution in the field. Finally, this cured and remilled acid phosphate, even under the best conditions of manufacture, must be shipped in paraffined or chemically treated bags to keep it from attacking the burlap.

These are some of the economic problems which still face the acid phosphate manufacturer even though he has been producing this commodity for over four score years.

Practically all of these problems would be solved if the manufacturer were able to shorten the time of curing and drying acid phosphate so that the finished product would be made in a few hours. Such a process would, at the same time, cut down appreciably on the quantity of acid required to render the P_2O_5 present available. Such a product would be more concentrated with respect to P_2O_5 , the cost of raw materials would be less, the danger of free acidity and corrosion would be reduced and a better physical condition assured. Here is a most interesting and fertile field of research for the chemical engineer.

DDOUBLE SUPER-PHOSPHATE manufacture involves the production of phosphoric acid, which is now successfully produced by two processes: The sulphuric acid method, which involves such varied steps as grinding, mixing, filtering, concentration and purification; the volatilization or pyrolytic process which comprises smelting mixtures of phosphate rock, silica, and carbonaceous material at a high temperature, the handling and combustion of gaseous products and such problems as cooling, absorption and electrical precipitation, all of which require a high type of chemical engineering skill. Only the sulphuric acid method of manufacturing

phosphoric acid is practiced today within the fertilizer industry, but the volatilization method is coming more and more into prominence since it offers a means of utilizing low grade phosphates and obtaining directly a concentrated acid.

No matter which method is employed in obtaining the phosphoric acid, the procedure from this point is very similar to that employed in the manufacture of ordinary acid phosphate. The acid is mixed with phosphate rock in such proportions as to give monocalcium (water soluble) phosphate. Unlike acid phosphate, double super-phosphate contains no gypsum and requires the application of heat to dry it and put it in the proper mechanical condition for distribution in the field. The product, however, contains as a rule three times as much P_2O_5 as ordinary acid phosphate and because of this concentration the process offers a means of saving in freight and handling charges.

THIS brings us to the latest development in fertilizer materials, namely, the production of concentrates or chemical compounds carrying the highest possible percentages of the three fertilizer ingredients.

The development of the volatilization method for phosphoric acid and the success of the processes for fixing atmospheric nitrogen have logically lead to investigations of methods for combining ammonia and potash with nitric and phosphoric acids to form definite chemical compounds such as mono- and diammonium phosphate, ammonium nitrate, potassium phosphate and potassium nitrate. These materials may be so proportioned and mixed that fertilizers having practically any desired percentage of the elements can be obtained. With the exception of ammonium and potassium nitrates, which have been extensively employed in the manufacture of explosives, none of these compounds have been produced in large tonnages, but the economic development of the pyrolytic process for phosphoric acid should make it possible to turn them out at a cost which will admit of their use in fertilizers.

The direct application to the field of double super-phosphate and other concentrates will involve a change in the present fertilizer distributors unless these materials are diluted with some material which is either harmless or beneficial to crops. It has been suggested that many of these compounds may be dissolved in water, and the solution sprayed on the soil, but this method is such a radical departure from standard practice that it is not regarded with favor.

The Bureau of Chemistry and Soils, U. S. Department of Agriculture, has done excellent and fundamental work on methods of producing these compounds and overcoming their objectionable hygroscopic properties. Carefully controlled field tests are also being conducted to compare their fertilizer value with that of the standard carriers of phosphoric acid, ammonia and potash.

WHILE the fertilizer business is dependent in part on such chemical engineering industries as the production of synthetic and by-product ammonia, the recovery and purification of potash salts, the production of Chilean nitrate, and the manufacture of sulphuric and phosphoric acids, this business is itself a chemical industry and one which vitally affects the wealth and prosperity of the nation. Moreover, those chemical engineering industries which furnish products for the manufacture of fertilizers are in turn dependent on the fertilizer industry for their present development and future expansion.

VEGETABLE OIL *Industry*

Pins Faith on

Ascendency of Engineer

By JOHN P. HARRIS

*Chemical Engineer,
Chicago, Ill.*

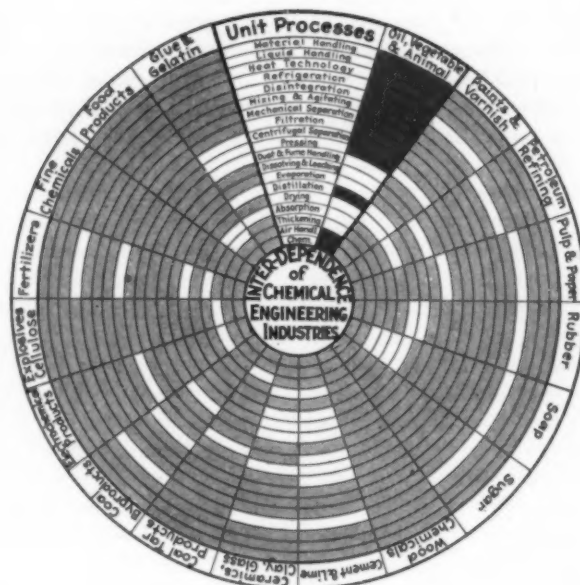
THE VEGETABLE OIL refining industry is dependent in every division of processing and of supplies upon chemical engineering and chemical processes. In fact, it owes its very origin and every stage of development to the ingenuity of chemical engineers and to the use of chemicals in the refining processes.

However, the refining industry is only one-half of vegetable oil production. The milling and crushing of seed and nuts for the production of crude vegetable oils has been noted for a lack of attention from the chemical engineer. It is interesting to compare the progress made by these two branches of the vegetable oil industry for it is indicative of the value of the use of chemical processes and chemical engineering control in any industry.

The principles of pure chemistry involved in the recovery of the oil from seed or nuts, and its conversion through neutralization, decolorization and purification into an attractive comestible, are comparatively few, yet the application of these principles in the manufacturing processes, involving chemical engineering, is manifold.

The absence of the chemical engineer from the oil milling field probably largely accounts for the almost total lack of important improvements since the industry's inception. The writer's personal contact with the mills goes back only a little more than twenty years, but veterans of the industry tell me that cottonseed mill products, especially oil, average definitely poorer in quality than forty years ago. Through all these years almost no attempt has been made to remove meal, settlings, emulsifants and detergents except by allowing them to settle out. If these impurities were removed by filtration after pressing, it would do away with a very large percentage of the off oil produced every year.

Meantime, the refining of crude cottonseed oil, particularly its development as an edible product, has progressed rapidly and steadily, until today salad and cooking oils and semi-solidified shortening are sold throughout the world by hundreds of millions of pounds. Here is an industry invented, planned and developed exclusively by the chemical engineer. From its humble introduction as a lard "substitute," and its early use as an adulterant, edible cottonseed oil has grown to such proportions that we witness the amazing spectacle of the meat packing industry calling for hogs with less fat! We cannot but feel that the lack of guidance by the chemical engineer in the packing industry, in the past, as against his employment by the edible oil industry, has acted adversely to the packer.



For the purpose of this article, I shall endeavor to sketch very briefly the history of the advancement of the edible vegetable oil refining industry through the medium of chemical engineering, treating each step in processing separately, and prognosticating slightly as to the future. In discussing plant processes I shall deal only with the production of edible vegetable oils, since the operating treatments there involved also cover production of oils to be used for soap, paint, etc.

NEUTRALIZING of vegetable oils is accomplished by adding sufficient of a solution of sodium hydroxide in water to the crude oil, mechanically agitated, at low temperatures, to neutralize the free fatty acids and to throw down the pigments, coagulants, emulsifants, meal, settlings and impurities. In this neutralization of free fatty acids, it is unfortunately true that on prime oil, an average of more than four times the weight of the free fatty acids, of good oil, is also thrown down and is thus lost as edible oil, being only available as the cheapest of soap stock. The loss to the cottonseed oil refining industry in the United States from this source has been estimated as two or three million dollars annually.

Little improvement in neutralizing has been accomplished, although much development work in the case of especially constructed treating tanks has been done. Some mighty good refiners, however, have told the writer recently that they get as good, or possibly better, results from the original square neutralizing kettle, with the mill wheel type of agitator, as they do with models of the latest improved design, and this coincides with his personal experience.

Recently, however, promising results have been obtained by a new process, suggested by the writer in several articles, whereby crude cottonseed oil is pretreated cold with the purely absorptive activated carbon Nuchar, to remove the undesirable color, odor and flavor and emulsifants prior to neutralizing. Early experiments indicate a reclamation of about 30 per cent of the free oil hitherto emulsified into the soap stock. Just where this development may lead remains to be seen, but it appears likely that it forecasts the complete reclamation of almost all free oil.

DECOLORIZING, or "bleaching," is the next step in refining. An attractive appearance is quite as important as any other consideration in modern merchandising, for the general public is prone to believe, in considering the purchase of shortening, that "if it's not white it's not pure."

No department of edible oil processing has come in for quite so much experimental work as decolorizing. The standard for decolorizing was set in the industry's infancy by the use of fullers earth, a siliceous earth imported from England, which was applied in powder form to the oil to be treated at 100 deg. C. This imported fullers earth is still a bleaching standard and, up to a few years ago, American fullers earths, although largely produced, were not very highly regarded. Today this is rapidly being changed, and there are a dozen well-known brands of domestic fullers earth on the American market, almost all of which outbleach imported fullers earths. A new deposit now being developed is reported to eclipse anything heretofore offered.

Fifteen years ago, with the development of "Filtchar" by the Industrial Chemical Company, activated carbon began to be applied to edible oil, being especially effective in the removal of red color. Today it is very extensively used, especially when properly balanced with fullers earth for maximum decolorizing results, reducing the total weight of bleaching materials and thereby the total oil retained.

Fats occur in nature free from oxygen, as such, and their subsequent inclusion of oxygen is always a true measure of their value for edible use. An absorption by deodorized cottonseed oil of less than 10 per cent of oxygen by volume is not marked by definite acid rancidity, and is revealed physically only to the most expert trained observer as a "flat" flavor and odor. But at about 15 per cent, this "flatness" gives way to downright, unmitigated rancidity, so that refiners cannot be too particular in minimizing opportunity for the absorption of oxygen in all processing. Fortunately, purely absorptive carbons have no oxidizing tendency, so that their use seems destined to increase. Many refiners employ a vacuum in closed decolorizing kettles to prevent oxidation, and this is quite effective.

DEODORIZING is the key process in vegetable oil refining and often spells the difference between good and bad operation. Early deodorizing merely consisted of blowing steam through oil at atmospheric pressure, exhausting the steam into the atmosphere with whatever volatile materials it carried away. Strangely enough, millions of pounds of oil and vegetable shortening are still produced annually by this crude method, although the process is generally somewhat improved by the employment of about 200 deg. F. of superheat in the live steam employed. Most of the edible oil produced commercially today, however, is deodorized by heating

under a high vacuum—the higher, the better. This not only substantially reduces the boiling point of the free fatty acids, but also prevents oxidation by excluding air.

To those familiar with the temperatures necessary for use in distilling fatty acids (440-480 deg. F. under high vacuum), it must be immediately apparent that, in the heating of oil with steam in closed coils, thereby raising the temperature slowly to a maximum of 380 to 390 deg. F., even under high vacuum, most of the live steam blown through the oil is wasted except for its agitating effect. Moreover, the temperature thus attained is not high enough for complete deodorization. Therefore, the chemical engineer has been busy devising proper heating processes whereby the oil to be treated may be quickly and efficiently raised to a temperature at which distillation of the undesirable fatty acids occurs.

Direct circulation of the vegetable oil through a tubular heating furnace has been much in vogue, but this method of heating possesses many objectionable features. For instance, if the circulating pump stops for any reason, even momentarily, the oil is burned and discolored, and costly damage may result to the tubes of the heater. Under the best circulating conditions, the product is liable to some deterioration by the direct application of heat to it. Difficulties are also experienced in maintaining perfectly tight joints in the pipe lines and pump, and leaks therein have a tendency to destroy the vacuum in the still as well as to admit oxygen to the oil.

The modern heating system for modern vegetable oils is the Merrill Process System of Industrial Heating, whereby a high flash mineral oil is heated in a properly designed heat absorber, and is then circulated through the coils or jacket of a vacuum vegetable oil treating vessel. This system produces final temperatures in the vegetable oil as high as are obtainable by the direct circulation method, but eliminates the objectionable overheating of the vegetable oil film. As the vegetable oil remains in the still throughout the entire deodorizing process, it simplifies the construction of these vessels, and because of perfect tightness, the highest vacuums are readily produced and maintained, reducing danger of oxidation to the minimum.

WITHIN the last twenty years Chemical Engineers have developed and perfected a system of synthesis, using finely divided nickel as a catalyst, whereby the necessary hydrogen is added to the unsaturated fatty acid molecule, saturating it and thus converting oil into the hardest of stearine. Hydrogenation may, of course, be arrested at any stage, and a measured amount of hydrogen may be admitted for the production of a product possessing the most ideal degree of hardness and mixing consistency. Such hydrogenation not only builds up a very stable, almost non-oxidizing product, but the reducing action of the treatment tends to destroy the adverse effect of any previous oxidation of the oil. It remains for the chemical engineer to develop the production of hydrogen on a large scale.

Refined edible vegetable oils are most largely used in the production of semi-solid shortening, salad and cooking oils. They are also largely used in the production of margarines, both alone and when blended with animal fats; as a medicinal base, as semi-lubricants, etc.

The ascendancy of the chemical engineer to practically complete control of this industry, which is, and has been, rapidly occurring within the past few years, assures an accelerated degree of future progress out of all proportion to precedent.

WOOD

DISTILLATION *Industry*

Turns Hopefully to the Chemical Engineer

By C. W. CLIFFORD

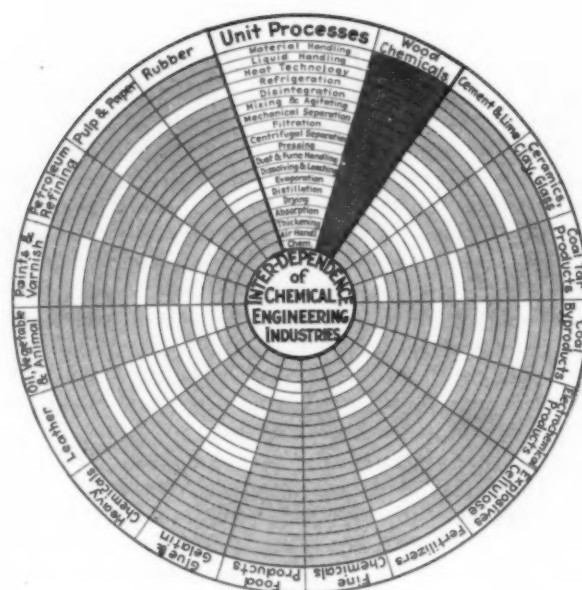
Escanaba, Mich.

THE HARDWOOD distillation industry on the American continent and in Europe has without doubt received a more severe blow from the production of synthetic chemicals than any other branch of the chemical industry. Synthetic acetic acid, acetone and methyl alcohol have all been hurled at this industry within the past few years, sounding what many believed to be the death-knell of two of its most important products—calcium acetate and methyl alcohol—if not the complete annihilation of the hardwood distillation industry. But the wood chemical industry has been hard hit many times since its inception in this country, and each time we have seen it emerge and resume its standing in the chemical world.

The past history of this industry impresses one with the rather empirical and carefree way in which it was conducted for many years, without any scientific supervision, content with such results as might be expected from rule of thumb methods. It is only within the last ten or fifteen years, during which the industry has been painfully conscious of a growing competition, that we find the chemical engineer associated with the wood chemical industry. Today, however, the chemical engineer is the key man in those plants that are prepared, or preparing, to meet the competition that synthetic chemicals created.

PREPARATION and pre-drying of the wood; temperature control during the carbonizing process, distillation of the crude pyroligneous liquor and concentration of the calcium acetate solution in multiple-effect evaporators; continuous stills for the production of high grade methanol; filtration of the neutralized liquor sludge in closed type leaf or rotary presses; drum and belt dryers for the drying of calcium acetate; direct fired and vacuum stills for the distillation of settled tar; these are a few of the advances which chemical engineering has brought to the hardwood distillation industry.

A number of plants today have almost entirely discarded the process of air-seasoning its chemical wood, a process entailing heavy expenditure in stocks and handling. Recently felled wood may be said to contain from 40 to 50 per cent moisture, while normal air-seasoned wood should contain from 20 to 25 per cent moisture. A chemical wood of this moisture content may be considered a favorable one for carbonizing. The reduction



of moisture content of freshly felled wood to that of air-seasoned wood will take from twelve to eighteen months, so that the wood distiller must carry on hand at all times from one to one and a half year's supply of wood. Chemical engineering has, to a great extent, removed this burden, and it is from this point that we will briefly survey the various steps in which this branch of chemical science has come to the aid of the hardwood distillation industry.

PRE-DRYERS, the capacity of which may vary from one to two carbonizing periods, are of the tunnel type, constructed of reinforced concrete, brick or hollow tile, and heated by the waste gases from the retort stacks. These gases are circulated in direct or indirect contact with the wood, entering first the primary dryer and passing on to the secondary, the wood in the primary dryer receiving the greatest heat. At the conclusion of its drying period the charge in the primary drier passes into the retort and that in the secondary takes its place, making the process a continuous one. With efficiently operated dryers it is possible to take the wood as received from the forest and in a 48-hour drying period, reduce the moisture content to that of normal air seasoned wood or lower if desired. This process not only offers a cheap and efficient method of reducing the moisture content of the wood, but supplies to the retorts wood already heated to a point which greatly assists the carbonizing process.

TEMPERATURE CONTROL is of great importance, both in the yield of valuable products, as well as the life of the retorts and settings. The yield of acetic acid and methanol may vary very considerably if this process is not maintained within certain temperature limits. Knowing the physical properties of the wood, its weight and moisture content, it is possible to plot a temperature chart for the individual charges for the guidance of the operator which will result in the highest possible yield of products.

Temperature control assures a more constant and increased yield of acetic acid and methanol, regularity of operations and considerable reduction in repair costs from overheated retorts and settings.

MULTIPLE-EFFECT evaporators have in many instances taken the place of the old time copper stills for handling the crude pyroligneous liquor. They are operated at low cost on exhaust steam under reduced pressure, and with their efficient cooling and condensing apparatus make possible the recovery of a distillate free from the entrainment of tarry bodies, resulting in finished products of a high degree of purity.

The distillate from these evaporators after neutralizing and settling is passed through a continuous column still for the removal of the methyl alcohol. These stills are most efficient in their operation, producing direct from the neutralized liquor a methanol of 90 to 92 per cent. The residual calcium acetate solution passes to triple effect evaporators where it is concentrated to 12 to 15 deg. Bé.

The great advantage which this equipment offers in the wood chemical industry is its low cost of operation. If exhaust steam is available in sufficient quantity, it is possible to operate the complete evaporating and distilling apparatus on steam of 5 to 10 lb. pressure.

Another process which until recent years called for considerable steam consumption and labor is the evaporation of the calcium acetate solution in open pans, from which the acetate was shoveled to the drying floors where it was spread and raked until the moisture content was reduced to 2 or 3 per cent. Although this method is still in use at a number of plants it is gradually being replaced by drum and belt dryers.

SLUDGE from the neutralized liquor tanks, which was formerly run to waste in many plants, is now passed through filter presses of the cylinder or closed chamber type. Many manufacturers do not fully realize the recovery available from the use of this efficient piece of apparatus. A plant carbonizing 100 cords of wood per day with a yield of 250 gal. of pyroligneous liquor per cord, will after it is neutralized produce 2,500 gal. of sludge containing the insoluble impurities from the lime together with certain organic compounds which are precipitated or polymerized during the process. This sludge upon filtering will yield from 2,000 to 2,300 gal. of liquor carrying about 4 per cent by weight of calcium acetate and 2 per cent by volume of methyl alcohol. In other words, the filtration of the sludge produces an increase in yield of about 800 lbs. of calcium acetate and 45 gal. of methyl alcohol. Many of the presses in use permit of an efficient washing of the cake for the removal of the last traces of acetate.

Settled tar, which only a few years ago was considered of no other value than as fuel, is now attracting some attention, and a few plants have installed direct fired or vacuum stills for working up this material.

Once a general nuisance, it is now a source of revenue considerably greater than the cost of the fuel which replaces it at the boilers or retorts.

THESE are a few of the processes which chemical engineering has within recent years introduced in the hardwood distillation industry resulting in lower cost of operation, reduction in labor and a higher yield of products. There are still many problems of the utmost importance to this industry awaiting solution. A more accurate method of determining the quantity of wood entering into the process is needed.

More even distribution of heat and better control of temperatures most favorable to quick drying with minimum fire hazard would improve pre-drying practice.

A study of the handling of the non-condensable gases and their purification, with the recovery of methanol and acetic acid which they carry by entrainment, should return dividends. Low temperature condenser water will limit, but not entirely eliminate these losses. Scrubbers have been installed at some plants with reported satisfactory results, but there is still room for considerable investigation and improvement.

A more regular and constant means of distributing the non-condensable gases throughout the retort battery for fuel purposes is desirable. These gases are produced in the largest volume with the highest fuel value at a period in the process when they are least required. The problem is to make them available for use when the heaviest firing is necessary to bring the charge rapidly to the exothermic period, and allowing of its extension over the longest possible time.

The possible use of producer gas from wood waste for augmenting the non-condensable gases from the retorts, allowing a reduction in the use of other extraneous fuels and the recovery of by-products from the gas producer should also be of interest to the wood distiller.

Another interesting problem is the development of a detarring process for the removal of the tar and tarry bodies carried in the pyroligneous liquor. Tar separators along lines similar to European practice, electrical precipitation, or an immiscible solvent suggest possibilities.

The direct extraction of acetic acid from the crude pyroligneous by such processes as that of Brewster or Suida, in which solvents such as ether, creosols and high boiling oils from hardwood tar are used are worthy of attention. The use of high boiling oils for this purpose should appeal strongly to the wood distiller since he controls their production. High boiling wood tar oils are suited for this work as they present less fire risk and loss from volatilization than the more volatile solvents. If an extraction process of this description can be successfully operated on a commercial scale, and glacial acetic acid produced direct from the crude pyroligneous liquor at low cost, it will be of the greatest assistance to the industry in combating synthetic competition.

Charcoal for the production of activated carbon and in the manufacture of gas for domestic and other purposes also deserves some attention.

ALTHOUGH chemical engineering has done much in recent years to assist the wood distiller in the improvement of his operations, increase his yields and lower cost of production, by the introduction of improved and modern equipment and methods of operation, it will be seen from this brief survey that there are still many problems to solve, much to be accomplished. However, we should view the future of this industry with optimism.

Chemical Engineering Processes and Equipment Adapted by RUBBER Manufacturer

By P. S. SHOAF

Manager, Chemical Engineering Division,
Goodyear Tire and Rubber Company,
Akron, Ohio

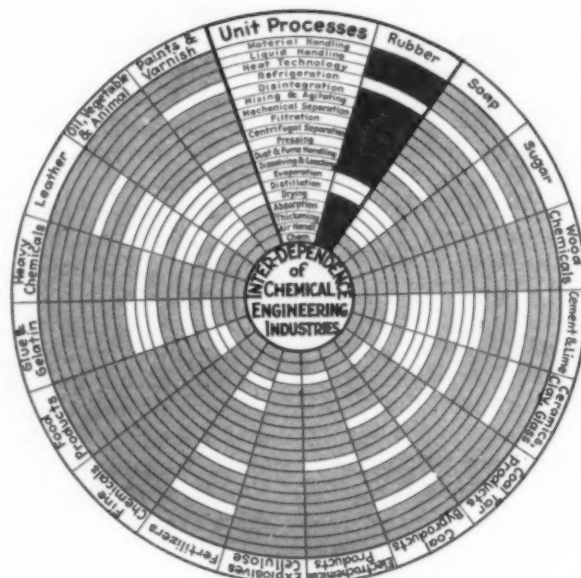
UNTIL fairly recently applied chemistry in its several aspects has played a somewhat minor part in the rubber industry. Not that chemical talent hesitated to take a major rôle but because the mechanical engineer with his more tangible offerings has had greater attention focused upon his activities. The mechanical engineer has made a wonderfully good job of it; the amazingly ingenious and efficient machinery, with which he has so greatly assisted in the attainment of mass production at lower costs, evidences his contribution to the industry.

Today chemistry and chemical engineering are assuming an increasingly larger share of the responsibility for progress, for efficiency and for products of uniformly higher quality. The compounder is a recognized, vital member of a rubber manufacturing organization. He is diagnostician, family physician and nurse for the multifarious ills affected by a temperamental and difficult subject. The man of pure research is being habitually sought as an ally in competition, and chemical engineering is being applied throughout the industry, whether under that specific title or as a part of the functions of other technical departments.

Others [Stringfield, *Chem. & Met.*, Vol. 33, No. 11, page 672 (1926) and Geer, *Ind. Eng. Chem.*, Vol. 19, page 1095 (1927)] have commented, directly or indirectly, upon the uses of chemical engineering in this field but we shall present again some general illustrations.

Real control of the manner in which rubber is coagulated from latex at the plantation factories is effecting increased yields and improvements in quality. "Bulk-ing" of batches of latex tends to reduce the variability of the product in its response to vulcanization. Washing and drying under regulated conditions are factors which at least react favorably in the effort to obtain clean, uniform rubber. However, there has been only a start in this direction. The inherently variable properties of crude rubber alone present a troublesome problem and certainly it is not lessened by differences in original treatments. Blending in the factory preparatory to compounding remains a necessary measure; even then, plasticizing of batches under varying conditions to suit the particular material is often a requisite.

Aside from economic considerations or a patriotic urge to free one of our raw materials from its geographic limitations, we may be justified in hoping for synthetic rubber at a reasonable cost solely for the reasons just outlined. It is fortunate that the rubber tree is so vicariously dispositioned as to give a valuable



milk; but it is hardly probable that *Hevea brasiliensis* ever had any thought of being parent to an automobile tire. Then one may ask, may not man some day, with yet another configuration of the elements and with a definite purpose in mind, evolve even a superior basic material?

In connection with the preparation of the crude rubbers it may be remarked that there is a real need for a large, efficient machine for plasticizing them previous to compounding. The question of effective cooling would no doubt be the most serious one to be faced in designing such equipment.

PREPARATION of the various constituents making up a rubber "compound" and mixing them to a homogeneous state involve chemical engineering principles and procedures. In addition to the blending and the previous plasticization of the raw rubbers, the fillers, reinforcing or inert as the case may be, and often the sulphur and accelerators must be specially sifted. The handling of softening agents also frequently requires special methods.

Mastication of the rubbers and of any substitutes and the incorporation with them of the other materials in a "mix" presents many interesting features. The factors of time, temperature, speed of mixing and the clearance between the components of the mixing device must all be studied and controlled. All influence the degree of interdispersion of constituents, the plasticity of the uncured compound and affect the ensuing processes as well as the characteristics of the finished articles.

For many years the machine usually employed for mixing rubber compounds has been the rubber mill. It

consists of two rolls rotating oppositely at differential surface speeds. The auxiliary equipment is a shovel, a brush and a short-bladed knife in the hands of a husky man. Variations in the mixing operation are liable regardless of rigid specifications and close supervision. In some cases there is applicable an improvement in the nature of an apron which continuously returns the materials to the "bite" of the mill rolls. Internal, closed mixers eliminate many variables and their use is increasing. Formerly used only for mechanical goods stock, they now find wide application for mixing tire stock and all grades of master batches, as well as for breaking down crude rubber in cases where large amounts of rubber compounds are processed. A heavy duty type of mixer is used for warming cold mixed stocks preparatory to calendering or tubing. Internal mixers have also been used to mass reclaimed rubber. The full employment of these machines is still somewhat limited in that cooling difficulties have so far made it impracticable to mix completely the sensitive, accelerated stocks so prevalent today, due to the fact that the internal mixer has less cooling area in proportion to the material handled. These difficulties are not usually troublesome when low temperature cooling water is available. The introduction of water or rubber latex direct to the batch at a certain time during the mixing cycle is a successful practice. Solution of the cooling problem should be accomplished with consequently greater uniformity of product as well as with incidental economies as compared with the more manual method of mixing.

In the process of impregnating and coating fabrics with rubber compounds as, for example, when preparing cord ply stocks for pneumatic tire carcasses and in forming tire treads by calendering or extruding the warm, plasticized, uncured stocks, the factor of temperature control is most important. Weights, gages and surface conditions are dependent upon the temperature of materials and machines and upon the manner and degree of subsequent cooling of the material although weight and gage are, of course, also controlled by the setting of the machine itself.

TEMPERATURE control in mixing, calendering and extruding operations is an extensive field of interest for the chemical engineer. The rubber industry among others has lagged in this control in preparatory processes. The plasticity of rubber is too much influenced by temperature for that factor to be disregarded. Neither scorched nor reprocessed rubber stocks ever paid dividends. It is recognized that it is always rather inconsistent to exercise extreme care in assembling and finishing articles unless their various constituents have been as carefully and uniformly prepared.

There is now much activity in an effort to utilize temperature indicating and recording instruments, to employ automatic control where practicable and thus to establish the most favorable conditions. A prerequisite for flexible regulation is an adequate supply of cooling water delivered at temperatures within definite ranges.

When the compounder adjusts the rate of cure of the parts of a pneumatic tire, as an illustration, and sets conditions for vulcanization, he studies and allows for varying distances for heat transfer. The vulcanization of inner tubes or other articles in open steam or in hot water calls for close control of time, temperatures, pressures and manner of bringing the heating medium in contact with the articles, in order to insure uniform cure.

In making cements the rubber technologist must select the proper solvent, must determine the preferable plasticity of the rubber and then follow good chemical engineering practice in obtaining solutions of uniform viscosity.

The manufacture of accelerators of vulcanization is partly an interest of concerns which do not process rubber or that find a profitable outlet for certain of their products in the production of the "kick" demanded by the speeding rubber industry of today. However, many of the strictly rubber companies are now manufacturing their own accelerators. Here is another instance where the chemical engineer is charged with doing on a large plant scale what the research chemist found possible with his laboratory apparatus. This type of development calls for not only a study of the process itself but also the adaptation of suitable types of equipment and often the designing of special apparatus. In this field that omnipresent, ogre-like enemy of metals, corrosion, is met and must be either conquered or placated.

RECLAIMING scrapped rubber is essentially a combination of processes familiar to the chemical engineer. It was not until the advent of abnormally high-priced crude rubber a few years ago with the consequently greater resort to rubber substitutes that chemistry and chemical engineering took their rightful places in this branch of the industry. The economic saving which the technical men in the rubber industry can make by the proper use of reclaimed rubber has been estimated to amount to 100,000,000 lb. of crude rubber per year, or the output of about 200,000 acres of plantation land. Its use also saves time, both in mixing and curing.

Most of the steps employed are similar in principle to those found throughout the chemical industry. As an illustration, in reclaiming pneumatic tires, following the sorting and blending of raw materials, there is the problem of grinding and sizing. Then comes the simultaneous removal of free sulphur, the destruction of the cotton fabric and the so-called devulcanization in caustic solution in high-pressure digesters, usually with the addition of softening agents. Next the digested scrap is washed and dewatered; and here we have the recovery of "fines" from the wash waters by continuous filtration or by centrifuging often preceded by a thickening process. This is followed by drying by any one of several well-known methods. The last step of milling and refining involves the use of machines more familiar to the rubber man, but again it is merely an observance of the principles of mixing, fine grinding and temperature control.

With the increasing application of chemistry and chemical engineering there has been improvement in the quality and especially in the uniformity of reclaimed products. Both have helped replace the derogatory name, "shoddy," with the more euphemistic term, "reclaimed rubber," since in the eyes of the resourceful compounder it now appears a more valuable substitute for crude rubber.

We have only briefly touched upon some of the points of contact of chemical engineering with the business of processing rubber. Yet these remarks may sufficiently serve to indicate its very definite place in the interrelated branches of this great industry. So far most of the data accumulated on rubber is only relative. When more of rubber's seeming eccentricities are explained by facts, chemical engineering will have a still broader field of operation.

FOOD PRODUCTS

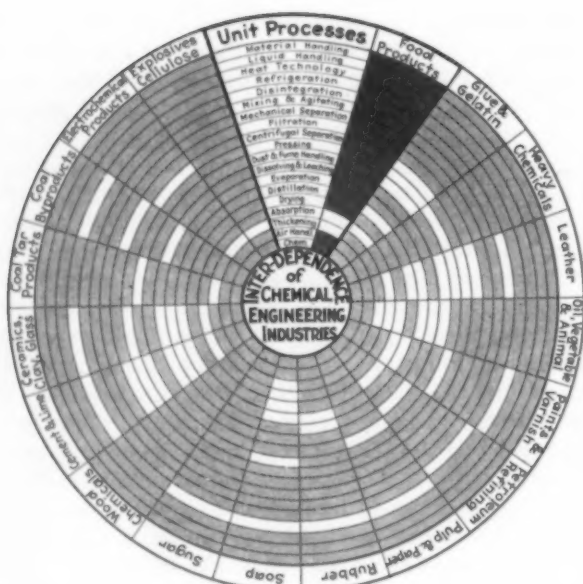
Industries

Find Scientific Methods

Universally Applicable

By F. L. SEYMOUR-JONES

*The Borden Company,
New York, N. Y.*



THE FOOD PRODUCTS industry of necessity has its roots in the soil. There they must remain, for the day of synthetic food, with a meal compressed into a tablet, is yet of the future. Since all primary food products come from Mother Earth, early attempts at preservation and manufacture started in the country. The farmer wishing to preserve his milk converted it into butter and cheese, or wishing to convert his grain to flour took it to a local "batch mill." From these the larger manufacturing units have grown—creameries, canneries, cheese factories, condenseries, flour mills.

The distinction between milk and grain exemplifies the great obstacle the food industry has to overcome. Where a product is rapidly perishable, such as milk, the factory must remain in the country. Where the product is dry, such as grain, the further manufacture tends to center in cities.

Broadly, where highly perishable material is dealt with, the industry not only starts in the country but remains there. It attracts a country type of man, and as a rule engineers and chemists are not found in the country as abundantly as in cities. Which fact explains the comparatively slow penetration of chemical engineering into that branch of the food products industry.

This does not imply that chemical engineering has not penetrated into the food industry at all. On the contrary, some of its branches are wonderful exemplars of technical operation and control.

The food industry comprises such a wide variety of products that nearly every unit process can be found exemplified in the manufacture of one product or another. There is great variation, however, in the methods of application, according to the product being manufactured. Thus, grinding may be the concheing of chocolate with the to and fro motion of rollers on a piston, roller crushing of grain, or the common grocer's coffee mill. Hence it is particularly difficult to generalize about an industry which includes everything from soup to nuts. What can profitably be pointed out is the fact that essentially chemical engineering processes and principles apply throughout, no different in principle from those used in rubber manufacture or tanning.

It would be easy to take each item on the menu and to show the part chemical engineering and engineers have played in placing it on your dinner table; easy, but too much space would be needed. Instead let us look at that very typical foodstuff, a loaf of bread.

FIRST and most important of its ingredients is flour. That flour comes to the bakery from the mills; the mills to make it bought grain. The wheat came from the farmer via a grain elevator. A grain elevator is not generally classified as chemical engineering equipment, yet where else can one see such perfection in the two typical processes of material handling and mechanical separation? Our grandfathers shovelled grain into the bin. Today everything is automatic. It is conveyed by air, buckets and belts. It is sorted automatically from foreign seed and is classified.

The grain reaches the miller. Once again conveyors handle it. By sieves and air currents it is cleaned and sorted. Disintegration is exemplified by the roller mills and mechanical separation once again by the automatic division into patent, clear and red dog.

Your loaf will certainly contain sugar, introduced either as finished sugar or already in solution as sweetened condensed milk. In either case, the sugar started from the cane or beet and encountered a whole array of chemical engineering processes. Handling of the raw cane or beets, crushing, extraction, purification and filtration, clarification, evaporation, crystallization, centrifugal separation and drying, possibly grinding to make the very fine confectioner's sugar. Sugar manufacture is emphatically a chemical engineering industry.

The next ingredient is salt, not much used in bread, but nevertheless very essential. Once again we see extraction, handling of the liquid brines, evaporation, crystallization and drying.

The shortening used in the loaf will very likely be a hydrogenated vegetable fat. For leavening, yeast is employed. These two ingredients are examples of about one hundred per cent chemical engineering industries. Very probably malt, or rather a malt extract will also appear in the formula. This represents a controlled fermentation in the malting of the grain, subsequent extraction of the malt and concentration in vacuum pans to syrup consistency.

Modern bakers, as well as housewives, use milk in making bread. Not only does this greatly improve the food value of the loaf but it also gives a bigger yield on the amount of flour used. Legally, a milk bread is one in which a third of the water used is replaced by milk or the constituents thereof. The last qualifying phrase permits the use of skim milk and butter. The "one-third" replacement originated in the fact that sweetened condensed milk was first used and if more than one-third was added it introduced too much sugar. More modern practice is to use dry skim milk. Where "milk bread" is required, butter is added and replaces some of the shortening. But dry skim milk alone improves the loaf in flavor, texture and food value. Besides these advantages it permits more water to be taken up by the dough and so gives a sufficiently increased yield to offset the cost of the dry milk. This is accomplished without exceeding the legal moisture limit for bread.

THE PRODUCTION of dry or condensed milk is slowly being recognized as another chemical engineering industry. The milk is received from farmers in ten-gallon cans and is inspected for quality. This involves daily sampling for fat and careful checks on its bacterial content. After inspection, sampling and weighing, it is immediately further cooled. If received at a feeder station it may be transferred to a glass lined truck for conveying to the factory. When used for dry milk it will pass through a heater to a centrifugal separator which separates cream and skim. Once more it is cooled and passed to refrigerated holding tanks, again glass lined. It is next pasteurized to destroy any pathogenic bacteria.

There are three general systems of drying in use; the roller, with or without vacuum; the spray, with or without preconcentration; the Campbell flake process. The hot roller is the oldest. The milk is fed on to a revolving steam-heated drum and the sheet of dry milk removed therefrom by a knife. More recently the roller has been placed in a vacuum jacket, permitting of lower drying temperature. In any case, the product requires grinding and bolting. It is not cold water soluble like that from the other processes, although the vacuum has helped in this direction. There are several varieties of spray dryers and they are used for many products other than milk; fruit juices for example have been successfully dried this way. The general principle involves the spraying of the hot milk through a nozzle or centrifugally into a current of hot air and collecting the fine powder resulting. Drying is practically instantaneous and a very fine product results. In the Campbell process the beaten concentrate is fed on to a diamond mesh belt which passes through a heated chamber. This permits drying at a low temperature, giving a product of unusually rapid solubility even in cold water.

Last but not least of our bread constituents is water. This can hardly be classified as a food industry, yet surely it exemplifies liquid handling, filtration, and corrosion.

So the chemical engineer plays no little part in producing that universal and typical food, our loaf of bread.

AWORD should be said about the bacteriological aspects of the food industry. Most foods, particularly those of a high moisture content, offer an ideal breeding ground for bacteria. Since the advent of pure food laws chemical preservatives are almost prohibited. A few, such as benzoate of soda, are still permitted if declared on the label but the general tendency is to avoid their use altogether. Preservation must be carried out in other ways.

Drying, as with dried milk described above, is very satisfactory. Where the moisture content can be reduced to less than about four per cent the keeping qualities are very satisfactory. Complete sterilization is naturally effective but it must be complete. The only general method is heat. Here the National Canners' Association laboratory has done splendid work on determining heat penetration through the can and material and on the thermal resistance of bacteria. The housewife's cupboard of canned soups, vegetables, milk, etc., is a tribute to sterilization. Then there are the foods preserved with sugar, such as sweetened condensed milk, or with acid, such as sauerkraut and concentrated buttermilk. Some foods change with age and in fact improve, cheese being a common example.

FOOD preservation obviously implies extremely sanitary conditions throughout the plant. Refrigeration is called on to prevent bacterial growth; heating (pasteurizing, sterilizing) plays its part in destroying bacteria. Equipment must be cleaned and sterilized, usually with steam or one of the common hypochlorite disinfectants.

The necessity for purity leads to the fact that material for equipment construction must be practically corrosion free and non-poisonous. Further the material must not react with the food to discolor it. Where foods contain sulphur or tannin this presents quite a problem.

Copper, sometimes tinned, is very commonly used for purposes where heat transfer is involved. It has also the advantage of not affecting the color of most foods, including beer if that may still be classed as such. Sanitary piping, tinned, with right-angled joints, capable of being taken down and cleaned readily, is useful in liquid food transfer. Pure nickel has to some extent replaced copper in vacuum pans and Monel metal is standard in several branches. It seems that there should be scope in developing the application of chromium plating and the chromium-nickel resistant irons to the food products industry. Glass lined equipment is extensively used for liquids. In fact some grade A milk is now shipped into New York City in glass lined refrigerator tank cars. As everyday examples of material suited to its purpose may be cited the ubiquitous glass bottle and tin can.

There is great opportunity for chemical engineers in the proving of suitable materials for the construction of equipment for the food products industries. Thus far, these problems have been left to the equipment manufacturer. There is unlimited scope in the process line, too, for with the conspicuous exception of one or two branches, the food industries are not over chemical-engineered.

The TEXTILE Industries

Need Influence of Chemical Engineering

By **ELMER C. BERTOLET**

*Head Department of Chemistry and Dyeing
Philadelphia Textile School,
Philadelphia, Pa.*

THE TEXTILE INDUSTRY is one of the largest in the United States, or, for that matter, in the world. Civilized man's need for its products is second only to that for foodstuffs, and to the establishment of proper places of shelter. It is an industry fundamental to civilization, and in this respect, as well as in the chemical relations it bears to them, is closely connected, on the one hand, with the paper industry, and on the other, with leather.

The basis of the industry lies in the various fibers, protein or cellulosic in nature, which man has adapted for the weaving of fabrics. With this inherent chemical connection with the leather and paper fields, it is certain that, as developments are attained in the one, that the others will feel the impetus of the work and will benefit thereby. Like the related industries, textiles, fundamental as they are to human needs, will always be produced. The industry is therefore worthy of the best that science can give it.

It is the intention of the present writer to show the mutual and reciprocal relations which textiles bear to the industries with which it contacts, and to indicate its relations, particularly, with chemistry and chemical engineering.

The textile industry has often been accused of being upon an empirical basis. In answer to this, it must be realized that, frequently, it is impossible to reduce the results of practice to mathematical formulas, or to adequately describe them on paper. It is a fact that experienced leather men can name the manufacturer of a certain piece of finished leather by its characteristics, particularly by the feel or the "handle." Similarly, this is frequently true in the textile industry. A man experienced in the handling of wool can tell the locality from which the wool came, by its "handle." Another example of the necessity for empiricism in textiles will illustrate this fact. A question came up some years ago with reference to cotton cloth used in making vacuum sweeper bags. A change was made in the source of the cloth. It was found that the new material would not retain the dirt, which blew through the cloth with the air. The analysis of the old and new materials showed that each sample of cloth had exactly the same thread count, and was of the same weight per square yard. Yet one of the cloths was entirely satisfactory while the other was not. The answer to the problem lay in the character of the yarn used for the cloth. The satisfactory material was made of a full-bodied yarn which acted as an efficient filter. Analytically, it was a case of two identical materials being different. They might or might not have been made from the same raw material originally, but there was a difference which could not be expressed by mathematical formula. In textiles, the eye or the "handle" of goods help to explain the comparative

properties of the two materials and their suitability for the desired use.

Every finisher of textile materials, no matter what the fiber, knows that the same construction of cloth might be sent to him by several customers, and that each of them might desire his goods to be processed to give a different character of finish. The finishing department of the textile plant must therefore, in almost every case, rely upon its experience in bringing about the effect. This requires individual attention for each customer's goods. In arriving at this end-point, the result to be attained is in a great measure determined by the senses of sight and feel.

To get a better understanding of the textile industry's problems, it must further be remembered that its raw materials are variable. Each animal or each plant that produces fiber is a distinctly individual chemical factory and must be considered so. Breed or species, environment and locality, climate and seasons are influences that affect the growing animal or plant and cause variations in the raw materials with which the industry has to work. All wool, for example, is wool; but all wool is different and must be carefully selected as the proper raw material for any fabric that is to be made. It is interesting to note in this connection that a sick sheep will produce weak wool and thin fiber during its illness. This can be easily detected in the fleece by the experienced wool sorter. Again, the wool raised in Ohio during one year will, and does, vary from that which will be produced in the same locality during, perhaps, the very next year. This causes the yarn made from Ohio wool to be variable; and deliveries, in turn, vary as the spinner sells the output to the trade for use in the manufacture of cloth. That yarn made from wool from any definite source is possible of wide variation, is not always known by many, even in the industry itself.

Again, the dyeing process while capable of being duplicated, in the majority of cases is so easily influenced by the many factors and conditions that arise in practice, that it becomes an art instead of a science.

The textile industry has also been criticized by those outside, as unprogressive. In the past it must be remembered as having been one of the most progressive. In the early days of American industrial life, it was the pioneer in the development of machinery to take the place of the hand-work in the home. The machinery of the industry has been developed to a high state of perfection, although the principles have not varied since the early days.

There is no industry that is less wasteful than this, in the use of its raw materials. If there is a waste in one operation, it becomes the raw material for another, and a use is always found for the last portions of the fiber. It is fascinating to see rags torn up, and without further treatment in some cases, made into yarn; and to follow this yarn through the weaving, dyeing and finishing operations, and then to view the wonderful result that is obtained in the finished material. There is an immense amount of fiber that is recovered and reworked which otherwise would be an economic waste. The recovery of millions of pounds of wool that can be reworked through the application of the carbonizing process is a definite achievement. This latter process is a combination of chemical with mechanical means.

IT CAN BE safely stated that few industries are independent of the textile industry. The automobile depends upon it for its furnishing and covering, and for the fabric that is used in tires, and during the manufacture of tires. The great electrical industry comes to it for its wire insulation and covering. The shoe manufacturer requires the thread and linings which the textile field has made available. Our homes would be barren, untenable places, were it not for the textile products which supply both the utilitarian and the æsthetic in their art, design and color. These illustrations are but an indication of the variety of uses which textiles must fulfill. When one considers that each textile material must be designed for a specific purpose, it is evident that the amount of detail and planning, as reflected by the finished products, is enormous.

The textile industry may be said to be a combination of mechanical and chemical methods and thus, is of interest to chemists, mechanical and chemical engineers. The fibers which are the basis of our processing are chemical or colloidal-chemical in nature and must be treated with chemicals during certain stages of their processing. Yet this chemical processing, in most cases, must be carried out with no idea of altering the fibers themselves, but rather, of removing extraneous matter that nature has used as a protection or aid to the fiber in its growth. Wool, as it comes from the sheep's back, is very dirty and contains large amounts of wool grease, dried wool perspiration, dirt, sand, branding paint, burrs and vegetable matter. The wool scourer must remove these impurities with no more than a minimum loss of the valuable properties possessed by the wool. Silk, in its original state, contains 20 to 25 per cent of silk wax or gum that must be removed at some stage of its processing without harm to the silk. The cotton fiber has five per cent of a cotton wax which, in many cases, must be removed without endangering the strength of the cotton. Linen is produced through a strenuous treatment of the stalk of the flax plant. It is a bast fiber and is obtained by retting the stalk and by mechanical means. The yarn or woven fabric that it produces is still far from white, and must be properly cleansed and bleached without affecting the fiber. In the bleaching of wool, cotton or any other fiber, the pigment must be chemically changed or destroyed without altering or deteriorating the fiber in any way whatsoever.

In the processing of textile materials either in the raw state or as they approach the finished condition, a large amount of several of the more common chemicals is required. The textile industry has thus become an outlet for much of the output of chemical industry. It is a large user of caustic soda, soda ash, sodium silicate,

borax and alkalies in general, soaps, oils of different types, detergents, ammonia, salt, sodium sulphate, alum, chrome, sodium sulphide, sodium bisulphite, sodium hydrosulphite, talc, clay, starches and gums, sulphuric and hydrochloric acids, acetic, lactic, formic and other organic acids, chlorine, sodium and hydrogen peroxide, stannic chloride, aluminum chloride, alum, sodium phosphates and heavy chemicals of too varied a nature to mention here. The amount of effort put forth to supply these materials, is in itself, no mean share of the total of the chemical industry of America.

The dye industry is, in the main, dependent upon the textiles for its outlet. The textile industry takes the output of all the rayon manufacturers, a volume which it is estimated reached a total of over 80,000,000 pounds in America in 1927. The production of this amount of artificial silk of various types, consumes great volumes of chemicals which were not necessary twenty-five years ago, when the manufacture of this fiber was in its infancy. The rayon manufacturer is one of the chief users of caustic soda in this country, and uses with it, large amounts of sulphuric acid and other chemicals. The mercerization of cotton, a process that has gained in importance since its start about thirty years ago, has likewise been responsible for the use of tremendous quantities of caustic soda and sulphuric acid. Mercerized cotton is a fiber that goes through both physical and chemical change, and becomes markedly different from the cotton from which it is made. It has increased luster, strength and affinity for the dyes used upon it. It is in reality a new textile fiber.

A fertile field for the chemical engineer in the textile industry is in the development of equipment to carry out the various chemical processes. Like the chemical industry in general, progress is dependent upon the equipment manufacturers. There is at the present time a group of manufacturers, both at home and abroad, supplying apparatus of various types, and it is through them that new materials of interest to the industry should be introduced. The surprising increase in the use of Monel metal as a material of construction for dyeing machines is an indication of the industry's willingness to accept a product that offered the dyer and finisher an improvement over the kettles in vogue.

AS ANOTHER EXAMPLE, during the last three years Alberene stone has come into use for the manufacture of dye jiggers for the dyeing of piece goods in the open width. At the present time, these jiggers have not had wide use, but if they pass successfully through the testing period, it may be that there will be a general acceptance of this material for this, as well as for allied uses. The equipment field of the textile industry, especially from the standpoint of dye application and other apparatus in which chemical substances are used, has shown remarkable development in the last twenty years, which parallels that of many other industries. This fact is a measure of the progress that is being made in this phase of the industry. Perhaps the best results in future machine development will emanate from the trained chemist, mechanical or chemical engineer, who, being in actual charge of the process, will be able to work with the machine builders in developing efficient apparatus.

The spinning, twisting, winding, weaving, knitting and some of the dry finishing processes, encountered in the textile industry, are strictly mechanical in nature. These processes have reached a high degree of mechanical proficiency. On the other hand there are many

operations that require the use of chemicals and these are always carried out in conjunction with mechanical equipment. These processes are the ones in which chemists and chemical engineers are chiefly interested. Some of the more common operations under the latter classification are scouring, bleaching, dyeing, printing, finishing, carbonization, mercerizing, coating of textiles in such treatments as rubberizing, oiling, or in treatment with pyroxylin, silk weighting, waterproofing and moth-proofing in all their many and varied details.

PROCESSES that use alkali or acid solutions or perhaps both as are met with in scouring, mercerizing, carbonizing, tin weighting and bleaching are fertile fields for chemical control, in that the product must be obtained near to standard. Titration methods, hydrogen ion control, and conductivity methods are finding a place and are doing away with the hit and miss procedure formerly used. The results obtained in this way have been very satisfactory in every case where they have been tried. The control of wool scouring baths, where soap and alkali are used, is just now finding a place in the discussions of textile chemists. Temperature control in all phases of processing has made possible steam savings. Automatic machinery, especially pilers, kier loaders, guides and like attachments have enabled the textile industry to save greatly in labor cost. The careful chemical control of processes is vital not only in the production of a more uniform product, but since it always brings about a saving in chemical costs, in addition.

Water is a prime necessity in the textile industry. What chemical engineers have done in this direction in supplying apparatus for the provision of sufficient water of the proper sort is well known.

The recovery of chemical by-products is not always carried out to the fullest possible extent in the textile industry. Some of the silk weighting plants, using tin (stannic) chloride, are enabled to recover considerable tin from the wash waters during the process. The method is quite simple and depends on the hydrolysis of the stannic chloride with the formation of stannic hydroxide. This is recovered from the liquors by sedimentation methods, the wash liquors being baffled as they are run to waste. The residue is filter-pressed and the hydroxide of tin obtained is usually sold to the manufacturers of tin chloride. Some of the larger weighting plants recover sufficient quantity of this material to do the whole operation themselves. On the other hand, there are many plants that make no attempt to recover tin as a by-product.

IN THE MERCERIZING of cotton, about three pounds of caustic soda in solution is required to mercerize two pounds of cotton. In some of the plants in this country, this is a complete loss since it is washed away. In other plants about 90 per cent of the caustic is recovered, at a low cost per pound, by evaporation and re-use of the properly collected liquor, through the means of triple effect evaporators. In one plant specializing in indigo dyeing, the entrance of a trained textile chemist, into the organization, enabled the plant, by a very simple process, to recover sufficient indigo, which otherwise would have been lost in the wash waters, to keep one strong vat going steadily on the recovered indigo; and this at a recovery cost of less than a cent per pound.

The practice of recovering wool grease from the soap-alkali scouring liquors in which raw wool is scoured, was carried out quite successfully with the use of the

centrifuge during the war, when the price of the recovered grease was at war-time levels, and grease was scarce. Material of U. S. P. grade was obtained in this way. The process has now, for the greater part, been discontinued as it is uneconomical today. An interesting side light on this last instance is that there are some plants in America that are recovering the wool grease by the centrifuge method as a means of preventing stream pollution, due to pressure exerted by state sanitation authorities. The prevention of stream pollution by wastes from textile processes is a matter that will grow in importance as time goes on, and will need the attention of chemical engineers.

The solvent method of scouring raw wool has permitted the recovery of wool grease and has led to economies in the chemical costs of scouring. The initial cost of these plants, using naphtha as a solvent, is high, however, so that there are but two installations of this type in this America and, I believe, in the world. Wool perspiration is one of the purest sources of potash known. In conjunction with the solvent method, a product obtained from the ignition of the dried wool perspiration, containing potassium salts, chiefly carbonate of potassium, to the amount of 50 per cent, as potassium oxide, was obtained in limited quantities during the war. Such products can frequently be recovered in the textile industry, but in many instances, the recovery is unprofitable.

THE FUTURE of the textile industry looks bright, but is dependent to a great degree on the advantage it takes of the application of chemistry to its processes. The industry's present depression is caused, no doubt, by lack of proper balance between supply and demand, and to certain abuses which the industry will have to correct. There is, however, an increasingly scientific viewpoint shown by the industry's personnel which speaks well for its future. The textile chemists have formed an organization, and are interested in the scientific study of many of the fundamental phases of the industry. They are attempting to co-operate with related organizations such as those of the laundry and dry cleaning industries, and are making efforts to become closely affiliated with the textile chemists of the entire world, wherever they may be organized.

The textile schools of the United States can, and have done much for the textile industry of America. The Philadelphia Textile School, which grew out of the Centennial Exposition held in Philadelphia in 1876, was the pioneer in this direction. There is an opportunity today for the textile industry to still further benefit from such institutions by the manifestation of a more decided interest in the maintenance and the welfare of these educational resources which have been established for the industry's aid. Textile research can best be done under conditions that bring it in direct contact with a staff organized to teach and study the problems of the industry.

The textile industry is not ordinarily regarded as one of the chemical group, but it is true that the application of chemical and chemical engineering methods has had a great deal to do with its progress. The recruiting of chemists and chemical, as well as mechanical engineers has been going on in the textile industry for some time. It is personnel of this type which will insure a strong and sure scientific foundation for the future of the industry. It is hoped that this paper will clear up for those outside this field, what before may have seemed to be hedged around with mystery, empiricism and an unwillingness to move with the rest of the world.

RECENT PROGRESS OF TECHNOLOGY

Editorial Staff Reviews

CHEMICAL & METALLURGICAL ENGINEERING is the successor to *Metallurgical & Chemical Engineering*, which, in turn, was a consolidation of *Electrochemical & Metallurgical Industry* and *Iron & Steel Magazine* effected in July, 1906.

The magazine was originally founded as *Electrochemical Industry*, in September, 1902, and was published monthly under the editorial direction of Dr. E. F. Roeber. It continued under that title until January, 1905, when it was changed to *Electrochemical & Metallurgical Industry*. In July, 1906, the consolidation was made with *Iron & Steel Magazine*, that had been founded 8 years previously by Dr. Albert Sauveur. In January, 1910, the title was changed to *Metallurgical & Chemical Engineering*, and semi-monthly publication was begun Sept. 1, 1915. On July 1, 1918, the present title was assumed and weekly publication was begun Oct. 1, 1919. Monthly publication was resumed in March, 1925.

Dr. E. F. Roeber was editor of the paper from the time it was founded until his death on Oct. 17, 1917. After a brief interim he was succeeded by H. C. Parmelee.

The staff of *Chemical & Metallurgical Engineering* comprises: H. C. Parmelee, editor; S. D. Kirkpatrick, associate editor; A. E. Buchanan, Jr., T. R. Olive, R. S. McBride and Paul D. V. Manning, assistant editors; H. M. Batters, market editor.

A New Institute for Industrial Research

AMERICAN industry, according to a recent estimate, makes an annual expenditure of \$200,000,000 for research in the laboratories of the United States. Since most of the progress of technology is directly traceable to this investment, it is a happy augury that the new year should have opened with the announcement of plans for greatly extending the facilities for organized industrial research.

The new Battelle Memorial Institute, which has been richly endowed from the estates of Colonel John Gordon Battelle, his wife and son, Gordon Battelle, adds another important agency for research in this country. While its main object is to be industrial research carried forward under a fellowship plan such as is practiced at Mellon Institute, the large income from the funds of the Battelle Memorial Institute are to be devoted to fundamental investigation and to "long-distance" research for the broad benefit of all of American industry. Organization plans are under way and construction of two new buildings at Columbus, Ohio, will be started shortly in order that the Institute's operations may begin during the fall of 1928.

The trustees of the new institute are to be congratulated on their selection of Dr. Gerald Wendt for the directorship. His own scientific attainments, his work in directing the co-operative industrial research project of Pennsylvania State College and his administration as

dean of the School of Chemistry and Physics have given him exceptional fitness for this new position. His is an unusual opportunity for organizing and directing an agency that may prove of incalculable value to industry and science.

Chemical Engineering Aids Pulp and Paper Production

LAST year witnessed the turning into production of the largest paper machine in the world, capable of producing a sheet 22 feet wide at a speed of 1,200 feet per minute. Thus the fourdriniers keep pace with the printer's whirling presses. So also must technology keep pace with the problems raised by the tremendous demand for newsprint.

For example, a supply of pulp for such large machines would require a beater room of tremendous capacity had not the chemical engineers of the paper industry discovered that pulp from modern grinders and digesters is virtually ready for the machine. Many mills now have systems for mixing these pulps in desired ratios and supplying the mixtures directly to the machines.

Equally dramatic in its rapid growth during the past few years has been the use of paper board for shipping containers and for building construction. The consumption of paper board in this country is now approximately equal in volume to that of newsprint, each of which represents one-third of the total paper consumption.

Numerous improvements and modifications in the sulphite process have been developed by the pulp and paper technologists for the pulping of hardwoods, such as maple and birch. The rayon industry, by its demand for exceptionally pure cellulose, has also brought about special methods of sulphite pulping.

Attempts to reduce the coal bill of paper mills have led to a detailed study of paper dryer operations. Several systems have been devised for using process steam more efficiently and economically. The vacuum dryer and the electric dryer, representing radical changes in design, bid for commercial recognition. The increasing application of the rod mill, modern sedimentation equipment, rotary filters for washing soda pulp and the economics effected by closed water systems testify further to the ascendancy of chemical engineering in the pulp and paper industry.

It is difficult to discern which of a pair of meshed gears is the driver and which the driven. Whether the tremendous demand for the products of the industry gave to technology its marked impetus of recent years, or whether the economics and improvements contributed by engineers are responsible for the progress of the industry is an academic question. The important fact is that technology is now smoothly geared to the production of pulp and paper.

Trends of the Year in Nitrogen Fixation

COMMERCIALIZATION of nitrogen fixation processes is proceeding so rapidly that the question may be asked whether or not the resulting products and derivatives can be marketed with an attractive return on capital invested. As coal, water and air are the primary raw materials of the industry, it is logical to assume that consumption of nitrogen products will be for the most part, within the national bounds of production. National self-sufficiency then, in nitrogen fixation is something that is being demanded by all the leading powers, both in the interests of agriculture and of the general welfare and security. Present action in Germany, Great Britain, France, Italy, Japan and the United States proves the point. This can be termed the *political* trend in nitrogen fixation.

As in any other field of commerce, markets for fixed nitrogen are being and will be created in two ways: first, by the displacement of other commodities, and second by the creation of new markets. Talk of the relative advantages of this and of that form of nitrogen is rather beside the point, as it is reasonable to suppose that in the course of events producers of nitrogen products will be able to supply any compound for which there appears to be an attractive demand. Sodium nitrate manufacture is said to be projected in this country, and when the producers of this salt feel too keenly propaganda in behalf of the natural article they may be compelled to add a little iodine to every lot to keep their customers happy! Price, and not propaganda, will in the long run be the controlling factor in nitrogen sales. A strenuous effort to reduce costs, in order that prices may be lower, can be termed the *economic* trend in nitrogen fixation.

Low costs presume technical processes in which every major economy will be practiced. Reviewing the process situation the following facts are significant: The arc process, admittedly successful only in conjunction with extremely cheap power, is not expanding further. The recent financial union and technical reciprocity between the Norsk Hydro and the I.G. indicates clearly that even in Norway expansion will be based on the Haber-Bosch process. Nitrogen fixation by the cyanamide process, while still commercially profitable, is assuming less and less relative importance. Hence nitrogen fixation and ammonia synthesis are becoming synonymous terms, and it is in ammonia synthesis that the most rapid developments are being effected. Consideration of any synthetic ammonia process reveals hydrogen production and purification as the critical *technical* problem. Electrolytic hydrogen, still championed in certain quarters, appears to have justification only for relatively small plants which have made unusually favorable power contracts. The choice among coke-oven gas, coke water gas, coal water gas and natural gas is a matter for individual initiative and development. Similarly, the method of hydrogen purification, whether by scrubbing, catalytic reactions, fractionation or a combination of any of these, will depend upon the particular circumstances of ingenuity and patent rights. Furthermore, with the widespread use of water gas as a source of raw hydrogen, it is also reasonable to suppose that considerable improvements will be made in the present Bosch contact conversion process.

Returning to consideration of markets, it is to be expected that the stiffest external competition in the United States will be from Chilean nitrate. At present,

Editorial Reviews of the

producers of synthetic nitrogen compounds are not seeking, and for that matter could not satisfy, the entire demand for agricultural nitrogen. It is believed, however, that the present period is one of development and intrenchment preceding the competitive situation that will unquestionably benefit that long-suffering individual, the American farmer. The objective as regards synthetic nitrogen costs will probably be the cost of Chilean nitrate delivered at United States ports, considering of course the inevitable slashing of the Chilean export tax, an improvement in extraction methods, and possible economies in handling. However, it is well to bear in mind that if opportunities for lowering costs of the natural product exists, there are most certainly opportunities on the side of the synthetic products. Producers of Chilean nitrate no doubt sense this situation, and will probably strive energetically to take their profits while they can.

A mention of the nation's position as regards nitrogen fixation may not be out of place. A recent editorial in a British contemporary points with pride to their own industry as compared with ours: We humbly submit, however, that substantial progress has been and is being made here (without government subsidies) and that commercial progress will meet adequately future needs. We believe the danger lies not in our falling behind in the procession of nations, but in being too far forward, with possibly the unpleasant result that huge sums may be bound up in obsolete, high-cost plant.

Low Sales Delay Advances in Fertilizer Technology

THE major effort of the fertilizer industry during 1927 has been directed to selling more fertilizer, but the aggregate tonnage sold was probably between 5 and 8 per cent less than in the preceding calendar year. However, the fertilizer marketed contained on the average slightly higher percentages of plant food, a continuation of the trend of all post-war years. Hence it appears likely that American agriculture actually used in 1927 as many pounds of plant food in fertilizers as in any preceding twelve months, and probably a greater tonnage than in any year except 1926, in which the record for sales of fertilizer was established.

With the use of more fine phosphate rock there has developed a need for better grinding methods. Considerable research is in progress in the industry on the procedure for superphosphate manufacture, using less acid and accomplishing the conversion at higher speeds. The technologic trend in this part of the industry is perhaps most notable. As yet there has been no commercialization of the much-talked-of phosphoric acid manufacture for fertilizer use. It is of interest to note, however, that the French rights to use the electrothermal method developed on a large scale by American engineers in the Federal Phosphorus Company have been acquired by the Société des Phosphates Tunisiens. The phosphoric acid thus produced will be largely converted into ammonium phosphate to be sold as a concentrated fertilizer ingredient. Thus a distinctly American development is to find its first application to fertilizer production in a European industry. The year 1927 should also be noted in respect to phosphates as the year in which the American industry decided to return to the original name

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"superphosphate" and abandon the objectionable term "acid phosphate."

The intensive competition between nitrogen sources, discussed at length elsewhere in this issue, continues to afford lower cost nitrogen carriers for fertilizer use. Moreover, careful work by federal and industrial agencies is making possible better grinding and mechanical preparation of these materials which contributes to more effective handling of concentrated fertilizer constituents.

Domestic potash production at Searles Lake has continued with reported increases in output. Definite proof was established during 1927 that certain areas in Texas and New Mexico are underlain with large deposits of high-grade potash salts. The commercial minability of the deposits has not yet been fixed, nor have any estimates been announced by the three groups which have done core drilling as to the probable cost of potash from this source. However, this definite proof of geologic forecasts made previously now sets some upper price limit above which American potash users will certainly never need to go.

Although the past year has not represented important technologic advances for the fertilizer industry or the suppliers of the three major constituents, nitrogen, potash, and phosphate, yet there has been substantial consolidation of business practice and distinct economic advance. Altogether, the year has been more encouraging than discouraging, viewed for the industry nationally, in both a technologic and an economic sense.

Process Refinement Marks

Carbonization Plant Trends

REFINEMENTS in coal processing, rather than fundamental changes in coking practice, have been the major contribution of 1927 to the coal-products industry. Those who anticipated that the year would show striking new developments in low-temperature coking have suffered some disappointment, but they can with satisfaction point to the erection and successful small-scale operation of a single-unit pilot plant using the Parr-Layng process at the Urbana Coke Company works. Other low-temperature processes have continued along lines previously indicated and they, even more than the Parr process, appear to remain in strictly development stages. It can be expected, however, that 1928 will afford some more striking advances, as it is promised that at least one large commercial plant using the K.S.G. system will be built in northern New Jersey.

There has been a distinct tendency toward an increase in amount of coal processed, both in gas retorts and byproduct ovens, for public-utility gas supply. In a number of cases important technical improvements in processing have been made in order that either the quality or the surplus gas available for this purpose might be increased. One of the most important trends which has taken on major proportions during 1927 has been the use of the combination heating system whereby retorts and ovens are fired at the will of the operator either with some of the coal gas or with producer gas made in a separate unit. This trend has also increased the extent to which fine coke is used by the producer and has thus helpfully influenced the coke disposal situation at works not connected with metallurgical plants.

Instrumentation of works and extreme effort for labor saving by automatic devices have continued markedly during the year. Exactness of plant control has thereby been gained and to some extent increases in plant efficiency are certainly traceable to this trend. In some plants the exactness of control has gone so far as to include the accurate maintenance of the temperatures of the fuel gas to the heating flues of batteries, in order that daily and seasonal changes in weather will not cause variation in oven temperature.

As a necessary consequence of this more exact control and of greater attention to gas quality and byproduct yields the coal-products industry is more and more adopting chemical engineering methods of plant operation. In fact, the modern coke or gas works is an establishment as far removed in type from the crude coal-butcher home of the gas-house terrier as is the elaborate modern abattoir removed from the pig-sticking procedure of the farm. Chemical engineering has penetrated rapidly and to every important operation of the business.

New Technology for

Synthetic Fibers and Plastics

RAYON has, on the whole, shown a year of improvement of existing processes and the extension of the older technique. With the demand consistently outstripping the supply, much of the energy of the producers has been diverted toward an expansion of existing manufacturing facilities.

There has, however, been an increasing realization of the limitation of the present synthetic fiber, and a real effort, attended with considerable success, has been made to improve quality, uniformity and wet and dry strength of the fibers. Much has been done in the way of development of the finer deniers and of yarns of greater filament count. In this connection, impetus has been given to American production by the large-scale introduction of the stretch-spinning cupra-ammonium process in a new Tennessee plant. Heretofore, nearly all of this type of rayon has been imported.

Among the new developments, perhaps the most important is the introduction of the flat, hollow rayon fiber. By proper introduction of inert gases into the spinning fluid, a semi-continuous hollow filament is produced which, when subsequently deflated, produces a new type of yarn for which much greater warmth and covering power, as well as decreased and improved luster are seen.

With the high luster of rayon once an important criterion of quality, it is interesting to note, that within the year, the trend has been toward reduced luster, more nearly approaching natural silk. On every side, efforts are being made to attain this result by producing discontinuous surfaces on the filaments and thus defracting the light rays.

Among synthetic plastics, widespread increase in the production of phenol-formaldehyde resins is noteworthy. The announcement of the urea-formaldehyde series, worked out in Europe, has been a source of much interest in that a possible substitute for glass, for certain purposes, is made imminent. With German producers now supplying urea for fertilizer purposes at a price commensurate with other nitrogen-bearing materials, a widely increased field for urea plastics is a reasonable prediction.

While the phthalic-glyceride resins are not entirely new, recent improvements in phthalic anhydride production have increased the interest in these resins. The

result has been that they are now being employed as binders for abrasives, asbestos and mica, as well as in lacquers. The unique properties which these resins possess may be expected to contribute to very interesting developments within the near future.

Vapor Phase Cracking Interests Petroleum Technologists

MAJOR interest in the technology of petroleum refining has lately centered in the possibilities of vapor phase cracking. The subject has long held the attention of the industry but it is only in recent months that a combination of market conditions and technical developments has appeared to emphasize its commercial importance.

During the recent period of over-production of crude oil, much high-pressure cracking equipment has stood idle. With the refiner getting no return on his heavy capital investment in this equipment there has naturally been a considerable reaction. This is noted in the tendency toward the development of low-pressure (almost atmospheric) vapor phase cracking equipment which will involve much lower investment cost. An added incentive lies in the fact that the product of vapor phase cracking has been found to possess such marked anti-knock properties as to be exceptionally valuable in the blending and compounding of premium motor fuels.

Some progress has been made during the past year in perhaps a half-dozen oil refineries, but if vapor phase cracking is to be widely adopted, there are economic, technical and perhaps legal difficulties to be met. Inherent characteristics of the process that have until recently appeared as disadvantages are the high yield of non-condensable gas and the production of a gasoline difficult to refine because of its higher content of unsaturated and gum-forming compounds. Fortunately the gas is of high B.t.u. value and if it were possible to sell it instead of gas oil to a neighboring gas company for enriching water gas, it should have commensurate value. The non-condensable gas also offers inviting opportunity for the recovery of alcohols and related solvents that are beginning to find an outlet in the lacquer industry. Promising research work in connection with the production and application of these alcohols has been under way.

The refining problem of producing a water-white gasoline from a vapor phase cracking plant is not especially serious in these days of green, blue and red motor fuels, although it is apparent old methods are not entirely applicable. Fortunately the industry has shown unusual willingness to study and adopt radically new treating methods. Mechanical difficulties arise principally from the fact that much higher temperatures are required. With good engineering design, however, and the selection of the proper materials of construction, it is believed that the mechanical aspects of the problem can be satisfactorily handled. The remaining obstacle is the question of patents. Admittedly it is complicated but an industry that has spent most of the last ten years in patent litigation is not likely to be easily discouraged on this score.

Paralleling interest in vapor phase cracking, there has been an intensive effort in the refining industry to reduce its costs through the introduction of heat economies, the reduction of losses due to corrosion and the increased efficiency of distillation and other refinery processes. Improvement in the average quality of motor fuel, particularly from the anti-knock standpoint, has

permitted developments within the automotive industry tending toward more efficient use of the petroleum industry's principal product.

The arrangement consummated during the year between the Standard Oil Company, of New Jersey and the I.G. subsidiary controlling the Bergius process for the liquefaction of coal, attracted international attention. Active prosecution of research now being carried on in the United States may be expected to develop the value of the process under American conditions. The work apparently carries most significance, however, as a provision for the day, seemingly in the far distant future, when the world's oil resources will no longer yield an adequate supply of motor fuel and related petroleum products.

Chemical Engineer Consolidates His Position on Pacific Coast

GROWTH and progress of industries utilizing the unit processes of chemical engineering on the Pacific Coast have been substantial and well defined during the past year. Based in most cases upon scientific research successfully completed prior to the commercial establishment of processes, the growth and future of the concerns responsible seem assured.

In the Northwest, the development has been predominantly that of the utilization of forest resources in the manufacture of paper pulp. Altogether the amount of money involved in new and projected pulp mills is enormous.

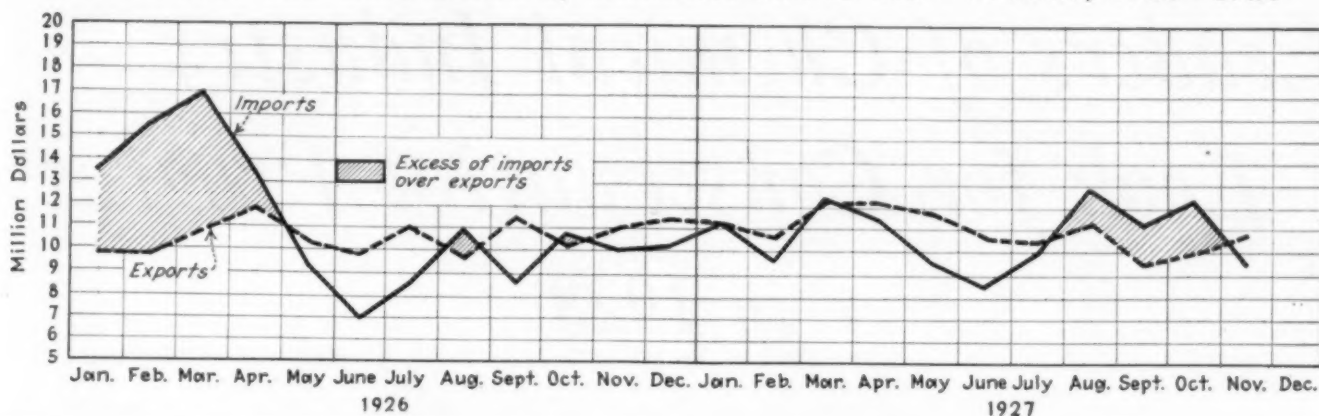
In the mid-Pacific Coast region there has been an increase in the manufacture of chemicals and allied products which are demanded for the needs of constantly increasing factories and population. One of the larger chemical companies is extending its operations to the Northwest with the proposed building of a half-million dollar plant for the manufacture of chlorine and other chemicals used in the pulp industry.

In the canning and food industries, several new processes have been developed, notably in the production of dried and evaporated milk. A new process for the production of fish meal from sardine waste products has transformed this formerly odorous business into an industry now desired even by the most fastidious communities. The conversion of agricultural waste products of the Coast into useful substances has brought out many new and ingenious chemical engineering projects.

Most notable advances are to be seen in the attainment of full production of borax and potash by the Searles Lake plant of the American Potash and Chemical Company and in the development of a deposit of a new borax mineral by the Pacific Coast Borax Company, so revolutionary that it has brought about the closing of the Death Valley workings. Reference should also be made to the establishment of a new \$100,000 research laboratory by the Celite Company at Lompoc, California, and the erection of the new plant of the Longview Fibre Company at Longview, Washington. The latter is first to install a new and important chemical recovery process.

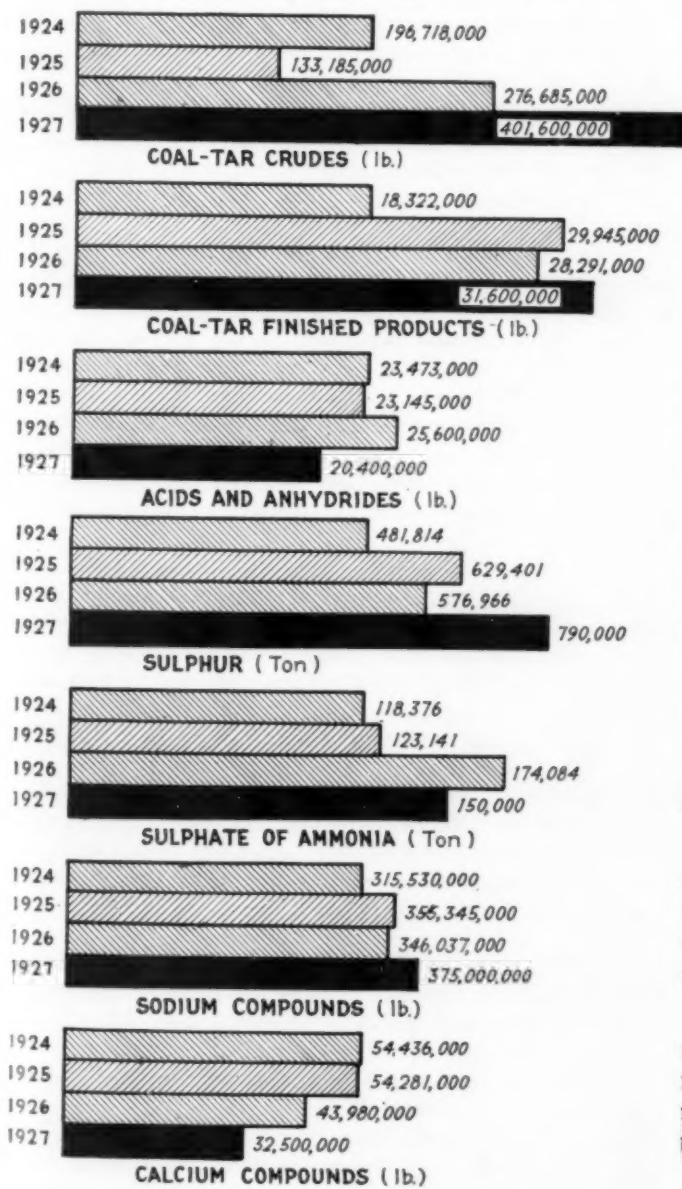
New chemical engineering developments during 1928 are to be expected in the food and paper pulp industries, in the byproduct production of soda ash, in the manufacture of bromine and allied products from sea water bitterns, and in the production and use of borax. All of these will result chiefly from research now being actively prosecuted.

IMPORTS and EXPORTS of Chemical and Allied Products, 1926 - 1927

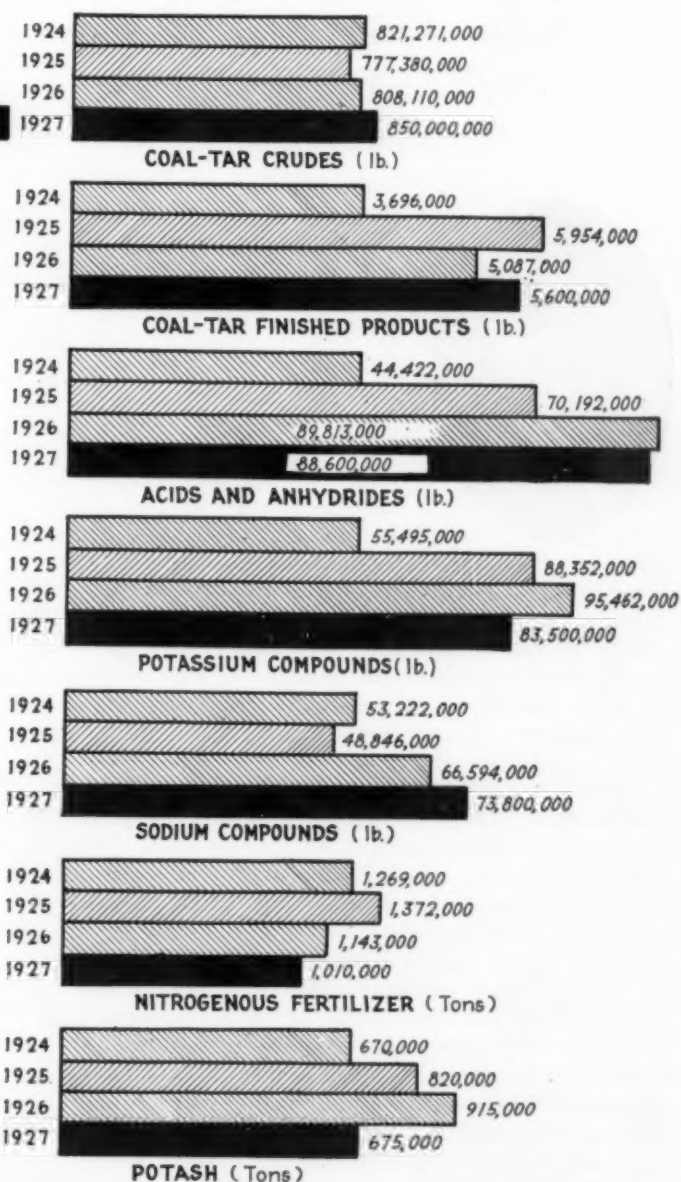


FOREIGN TRADE IN CHEMICALS

EXPORTS by Groups, 1924-1927



IMPORTS by Groups, 1924-1927



0 50 100 150 200

Per Cent of 1924

0 50 100 150 200

Per Cent of 1924

Leaders of Chemical Industry Look for Conservative Progress in 1928

Business as a whole in 1927 fell slightly below high levels of preceding year but stable production and consumption seem assured

Chlorine Prices Hold Below Prewar Levels

By John A. Kienle

Vice-President, The Mathieson Alkali Works, New York



MANUFACTURERS of liquid chlorine and bleaching powder, especially the former, are at this time confronted with the unfortunate condition of excess plant capacity and over-production. It also seems obvious that were it not for the inherent characteristics of these commodities, in that they are not readily adapted to storage except at considerable finan-

cial loss, the over-production phase of this industry's problem might assume an even more burdensome aspect. The situation so far as the future outlook is concerned cannot be said to hold any particularly bright prospects due to the entrance into the industry of additional capacity at two locations, adding to merchantable production approximately 15 per cent to 20 per cent of the total heretofore marketed.

As a result of the economic evolution in the use of the products of this industry a radical conversion from the use of bleaching powder to the use of liquid chlorine, particularly in the pulp and paper industry, began shortly after the close of the World War. This change soon caused a price conflict between these relatively similar products which resulted in a low price for chlorine, during the clash, approximating fifty per cent of the prewar level, with consequent heavy losses to all manufacturers. A subsequent recovery to a more rational level ensued, yet it is very interesting to note that although a fairly uniform and stable price has prevailed over the last three years, chlorine is one of the very few basic commodities which during that period sold at least 25 per cent below prices prevailing in 1913-1914, and is offered today at 35 per cent less—such a condition could under no circumstances have prevailed in prices for

bleaching powder without causing utmost distress and I daresay the complete ruin of some manufacturing units in that industry.

Obviously the conversion to liquid chlorine resulted in many economies both as to manufacture as well as to the use of the product, otherwise such a sales price structure could not have existed, yet unfortunately for producers, the attractiveness of price has not, nor does it seem likely that it will, stimulated new uses of the product.

An outstanding increase in the use of chlorine gas during the past year has been in the manufacture of such solvent materials as ethylene glycol, amyl alcohol and related products. While these special chemical uses of chlorine now represent probably the largest single consumption of the product in the United States and possibly in Europe, they have not been responsible for any material relief to the over-capacity condition of the industry.

In the hope that some other large consuming use of direct benefit to the commercial producers of the product might be discovered, there was formed some years ago, a Chlorine Institute, composed of 90 per cent of all chlorine manufacturers, for the main purpose of conducting research along those lines, and the most promising field ahead appears to be chlorination of industrial wastes and the disinfection of municipal sewage. Although chlorine is used extensively in the sterilization of public water supplies generally throughout the country, this manner of chlorination having become standard practice, the actual consumption in this field is relatively small and increases but slowly each year. The increasing density of population in the states east of the Mississippi and the numerous sanitary problems arising from greater mobility of this population brought about by motor car, places a growing burden on drinking water supplies. In such conditions liquid chlorine is literally invaluable. In the recent flood disasters on the Mississippi and in Northern New England the State and National health authorities drew on the industry for very considerable supplies of chlorine, chlorinators and technicians. The Wallace & Tiernan Co., Inc., for instance, maintained a 24-hour day emergency motor truck service in New England, and equipped with every neces-

sity for chlorinating flooded and polluted water supplies, and rendered great service.

The transportation of liquid chlorine is an interesting technical feature of the business and has been brought to a high state of efficiency. Accidents are very rare and in the nineteen years of liquid chlorine transportation in the United States of America and Canada there has been no serious accident on rail or water. This is the result of long years of experience in handling chlorine shipments by the manufacturers themselves, and eliminating possible accidents from inexperienced middlemen. There is a growing tendency to supplant the Class "V" tank car of fifteen tons capacity each with the multi-unit type having fifteen one-ton tanks removable from the car frame. This car was introduced into American commerce by the Mathieson Alkali Works, Inc., and this company has made it available to the chlorine industry generally for the benefit of producer and consumer alike. It is an outstanding contribution to the safe handling of liquefied chlorine, decreasing the hazard of such a large amount of product in one unit, and is already in use by makers of other liquefied gases.

Although the volume of business in both chlorine and bleaching powder in prospect for 1928 will no doubt equal that of 1927, it seems quite clear that any immediate developments likely to materially increase the consumption of either will be those capable only of a very gradual growth, and that the industry's immediate problem can only be satisfactorily met by a sane and reasonable administration of manufacturing and selling programs on the part of the various manufacturers, if considerable of an economic loss is to be averted—a condition which is not desired by the consumer, who as stated above is now buying liquid chlorine 35 per cent cheaper than the prewar prices.

Material Gain in Domestic Output of Potash

By John E. Teeple

Consulting Chemist and Engineer, New York



TOTAL production of potash in the United States for the year 1927 will be nearly 50,000 tons computed as K_2O . This is approximately 20 per cent of America's consumption of potash and is a very definite increase over the production at any time in the past, excepting the one war year of 1918, when our production also amounted to about 50,000 tons. The extensions to the plant of the American Potash & Chemical Corporation were completed early in 1927, and during the succeeding months the operation gradually became standardized. This extension caused the only considerable increase in production during 1927. As has been the case for the last few years, this one plant probably accounts for more than 85 per cent of the total potash made in the United States. The U. S. Industrial Chemical Co. produces about 10 per cent of the total, and the remaining 3 per cent to 5 per cent is byproduct potash coming from a variety of sources. No new sources

of potash have reached commercial development during the year, and none is in sight for the immediate future. Explorations are still being continued for potash beds in Texas and New Mexico, and findings of potash are reported, but it still remains to be shown whether any of the deposits there are commercially workable. Some work has been continued on greensand, and no doubt on other possible sources with which we are familiar, but none of these has yet reached a stage where it has any effect on the market.

The price of potash has averaged slightly higher recently than it was in 1926, but the increase has been very small, and potash is still one of the very few large scale commodities selling at approximately its prewar level.

In the not distant future the farmers of America will surely use intelligently and to their own advantage a great deal more potash than they are using today. The production of the American Potash & Chemical Corporation in California is now on a thoroughly stable basis, and is here to stay permanently so far as one can foresee at present. The question that formerly agitated the newspapers so much, "Can America have a Potash Industry?" has apparently been conclusively answered. She has one.

Wider Outlets Sought for Silicate of Soda

By James G. Vail

Secretary, Philadelphia Quartz Company, Philadelphia



THE SILICATE of soda industry is characterized by a great diversity of uses of which a numerical majority is, from a tonnage standpoint, unimportant. The major outlets are for adhesive uses and detergents. Bar soaps for household purposes and, more recently, sodas for building soaps in commercial laundering are the principal detergents in which silicates are

largely employed. The making and sealing of fiber shipping cases either of corrugated paper or from flat sheets laminated with a silicate adhesive, and wall boards, are the most important adhesive uses. Due to improved practice a unit of silicate makes more boxes today than a few years ago.

Low unit cost of silicate of soda, the demand for silicate solutions rather than for solids requiring special apparatus to dissolve, and the large percentage of freight in the costs of the ultimate consumer have in recent years increased the number of local units and tended to circumscribe the territory served by each.

Some of the older plants have, during the past few years, been encircled by newer units built with the idea of living on the saving in freight. Small units inevitably entail high cost and a vigorous effort to obtain additional tonnage. The year was marked by price recessions, even from some previously very low levels and smaller producers with inevitably higher cost have felt the disadvantage sharply. Some efforts at consolidation have resulted. Announcement has been made of the purchase by Philadelphia Quartz Company, as of January 3, 1928, of the silicate plant of Central Commercial Company at

Utica, Ill. At least one large consumer is planning to abandon its own manufacture and purchase its silicate supplies for 1928.

Volume for 1927 may be regarded as normal, both of the major uses having shown moderate growth. Producing capacity is still very much above demand. The industry is so closely associated with miscellaneous freight moving in fiber cases that output closely follows general carloadings, which have been less in the last six months of 1927 than the corresponding period of 1926. This recession is partly offset by the advent of new uses for fiber cases.

For the coming year producers anticipate moderate volume with increased pressure on selling values. The need for wider outlets is causing the larger producers to make substantial expenditures for research and development of new uses. These, however, usually bear fruit slowly.

Synthetic Ammonia Industry Makes Progress

By R. J. Quinn

Assistant Manager of Sales, The Mathieson Alkali Works,
New York



IN LAST year's review of the anhydrous and aqua ammonia situation, attention was called to certain basic economic trends which were quite obviously in process of development. At this time, a year later, it is interesting to note to what an extent this development has progressed. The predicted development of an American synthetic ammonia industry has proceeded in a logical and orderly manner. During 1926 seven synthetic ammonia plants were operating and another was in stand-by condition waiting for a favorable opportunity to enter the field. During 1927, two of the seven discontinued operation, apparently for good, and the remaining plant has been successfully utilized for the production of synthetic methanol. The two plants which ceased operating were apparently unwilling to continue activities which were quite obviously unprofitable and which offered very limited encouragement for the future. This took effect early in the year, and the remaining plants were able to operate all year at full capacity and accordingly at reasonable cost.

Valuable experience and improved technique have been acquired during the year, and from an operating point of view, the synthetic industry has adequately organized a highly trained and thoroughly experienced personnel.

In addition to the removal of this excess production or potential excess production of synthetic ammonia from the market, there has been a noticeable decline in the production of byproduct ammonia due to decreased demand for byproduct coke. These conditions have brought about a more evenly balanced relation between supply and demand and have resulted in some stabilization of prices for both anhydrous and aqua ammonia.

Increasing efficiency in methods of distribution and improvements in competitive merchandising of the products are also noteworthy. A satisfactory volume of busi-

ness appears to be contracted for 1928 and the industry is entering the new year in a well sold-up condition. An optimistic tone is apparent and with moderate increases in price, the industry will be placed upon a profitable basis.

No particularly important or new uses for ammonia have been developed during 1927. Ammonia oxidation shows an increasing tendency and will continue to offer a desirable outlet. Imports of Chilean nitrate have been reduced on account of this trend and while the price of nitrate was noticeably depressed early in the year, it has resumed a sufficiently high position to make ammonia oxidation of continued economic interest.

The transportation of relatively large quantities of anhydrous ammonia in tank cars is increasing to a very marked degree. Facilities for this movement are available in adequate form to meet the demand and this expansion in container equipment promises encouragement for new and unusual uses for the product.

Rising Trend to Values for Mineral Acids

By P. M. Dinkins

Vice-President, The Kalbfleisch Corporation, New York



THERE WAS a marked decrease in the consumption of sulphuric acid by the fertilizer industry during the first six months of 1927 as compared with the same period of the previous year. The figures for the second half of 1927 will not be available until sometime in the Spring of 1928, but indications are that a good portion, if not all, of the loss in the first part of the year has been made up. Production and consumption of sulphuric acid in other industries has shown a healthy increase. This also applies to muriatic acid and nitric acid. In some localities the demand for sulphuric acid has been such as to create what amounted to a temporary shortage. This was not unexpected, in view of the limited storage facilities for this acid, and the temporary under-supply was not sufficient at any time to cause any difficulty.

Distribution of the mineral acids has proceeded along the same well ordered lines as in 1926, and the placing of a large volume into the hands of the consumer seems to have been accomplished without any disturbance.

Prices of all mineral acids have been very firm, with a tendency of bulk acid toward somewhat higher levels. These very important raw materials of industry are still considerably lower in price, compared with their prewar levels, than most other commodities, and it is to be expected that this condition will at some time in the future be altered. Contracts for a period of at least one year are certainly desirable from the point of view of the consumer as the price tendency has been upward for the past several years. This, of course, has been enhanced by the recent increase in the price of sulphur. On the whole, one would expect to see prices of the mineral acids slowly but steadily increasing until the return to the manufacturer is more nearly in line with that of other basic commodities.

There have been minor improvements in the manufacture of sulphuric acid, but no radical changes seem to have occurred. The same can be said of muriatic acid, but when one comes to nitric acid there is a different situation entirely. We are already hearing of plans for the production of nitric acid by ammonia oxidation. How soon these plans will materialize and nitric acid made by this process placed on the market, no one seems to know. What effect the appearance on the market of this synthetic nitric acid would have on the price is hard to foresee, although it is not to be expected that there will be any marked revision. With ammonia prices stiffening somewhat, and synthetic nitrogen playing such an important part in the fertilizer industry, it will be interesting to see what reflection, if any, this development has upon the nitric acid market.

Important new consuming outlets for the mineral acids are not large in number. Their increased consumption depends largely upon increase in general manufacturing, including the production of fertilizer. The rayon industry, as a unit, is growing rapidly and, with this growth, is consuming more sulphuric and other mineral acids. It is to be expected that this increase in consumption will be steady over the next few years. Some new uses

for the heavy acids come into existence every year and the aggregate of these is certain to make the consumption curve one that tends steadily upward.

The industry, as a whole, is in much the same position as it was about a year ago. The increase in the price of sulphur has been felt keenly, and the advances in prices made by leading manufacturers of mineral acids have not been adequate to compensate them for the increase in the price of sulphur. There will undoubtedly be other advances in the future.

There has been no unusual expansion in the industry during the past year, and facilities in existence at the present time seem to be entirely adequate to take care of the growing consumption. The prices are still low, as compared with other commodities and as compared with mounting costs of manufacture.

The prospects for the year 1928 depend, of course, upon the prospects for industry as a whole. If we agree with the optimists that 1928 will be as good a business year as 1927, or better, then we can expect to see the mineral acids industry proceeding on an even keel, with a healthy balance between production and consumption. This seems to be the consensus of opinion and certainly the desire of all connected with the industry.

Improved Dusting Equipment in Insecticide Trade

By R. N. Chipman

President, Chipman Chemical Engineering Co., Inc.,
Bound Brook, N. J.



AGRICULTURAL insecticides and fungicides were under considerable pressure during 1927. In fact, the past year has been one of the worst witnessed with respect to price and competitive pressure. Weak methods of merchandising contributed largely to a campaign of price cutting. Production programs throughout the industry resulted in an eventual surplus at the end of the season. Keen competition is, of course, the spirit of the day and in many industries the survival of the fittest seems to be clearly before us. Insecticides, however, have suffered an additional factor in the actual shrinkage of volume during the last two years. This has accentuated the situation almost to a disastrous point. The shrinkage in volume has been due to excess expansion in 1922 and 1923, both in the fruit-growing and cotton classes of consumers. The volume reduction is not an unhealthy sign but more or less a reaction from the unhealthy propaganda resulting from boll weevil publicity campaigns and certain ravages of insects which at first seemed to excite the entire nation.

The industry is a sound one essentially and will grow more necessary to agricultural efficiency as intensive farming increases. The farmer will not always take chances with his soil conditions, insect ravages and the weather. The most prosperous farmers are learning the value of insurance by using soil stimulants, insecticides and proper methods of cultivation. The industry should look to a healthy growth in the future. The purchasing

should be less erratic and based on insurance value rather than particular use during a last-minute necessity.

New developments within the industry have been minimized by the industrial condition but there has been some progress. The principal improvement has been in the use of dusts versus wet sprays. Dusting equipment has been improved to a point where waste is prevented, perfect coverage of the plants attained and a distinct saving of time and expense in application. The use of dusts has resulted in some changes in the physical and chemical form of insecticides, particularly in the Bordeaux mixtures being substituted by mixtures of copper monohydrate with lime, whereby this mixture is dusted on the plant and forms Bordeaux in the presence of moisture.

Improvements in the mixture of sulphur compounds to conform with dusting requirements has been quite marked within the last year. Co-operation between government authorities, fruit growers and manufacturers of agricultural insecticides has resulted in a great improvement in the methods of marketing fruit.

It would hardly be fitting to write any word on the question of insecticides without mentioning the calcium arsenate use against boll weevil. This business has suffered many kaleidoscopic changes and today is in the process of finding a permanent base. There is no question but what calcium arsenate is desired in an emergency. There is some question as to its general utility under ordinary insect invasion but I think this question is only unsettled in the minds of the careless or unintelligent grower. It seems perfectly clear that eventually the grower will realize that the expense of calcium arsenate applied to cotton fields will yield an average profit.

The new season of 1928 will, in no way, solve all the difficulties involved in the industry but there is a full appreciation of the value of modest manufacturing schedules within the industry and it is hoped that merchandising methods will improve. Natural circumstances must eventually bring this about but the industry must await the day whereby low selling prices and efficient methods of distribution force this more satisfactory conclusion.

Coal Tar Industry Favored by Conditions in Europe

By William E. Jordan

Manufacturer's Representative, Brooklyn, N. Y.



REVIEWING the coal-tar products industry for the past twelve months shows nearly all of these products in a healthy condition with perhaps the exception of pitch. In fact it is doubtful if the industry was ever in a more favorable position since the great war. This is due particularly to conditions in England and on the Continent. Great Britain has not fully recovered

from the strike, as well as a dullness in the steel industry causing a reduced production from the coke ovens which in turn affects the supply of tars and the resultant byproducts as creosotes, cresols, cresylic acid, etc.

Europe is using increasing quantities of tars for road improvements. It is estimated that about 1,000,000 tons is consumed annually of which about 300,000 tons is used by France and about 400,000 tons by England.

France has developed new coke oven operations in the northern and eastern coal fields and brought about a steady increase in creosote oils. It is expected the output of creosote oils from this source will yield 80,000 tons in 1927 although exports from France of coal-tar products are prohibited except by permit. In August 4,400 tons was cleared for the United States. This creosote is the wood preserving grade of which there is insufficient supplies in the United States.

The demand in Europe for tar products such as crude tar, pitch, benzol, etc., has been only fair, due partly to the rainy season.

Creosotes of the various grades for wood preserving and disinfectant have been in steady demand at good prices with the prospect of greater demand and even better figures.

It is some years since cresylic acids and cresols have been as scarce as at the present time and this is due in part to the conditions in England. As previously mentioned, the volume of tars is short. The refiners are removing the phenols and allowing the cresylic acid to remain in the creosotes because of the present high prices of the latter. Further than this the sale of cresylic acid has increased in the rayon industry abroad and in the mining industry on this continent.

Germany has supplied considerable cresylic acid in 1927, mostly going to the mining industry and will probably do as well in 1928.

The light distillates such as benzol, toluol and xylol have been in steady demand at fairly uniform prices, especially in the East. In the West some competition caused a cut in these prices. The future looks good for these products in the rubber and lacquer trades and with an increasing export demand for Cuba and Argentina.

Napthalene has been supplied to the refiners from domestic sources. Formerly much of this was imported but because of the present European situation, the consequent high prices make its importation practically prohibitive especially at the present prices for the refined as quoted for next season.

The outlook for 1928 in the United States is gratifying and predicted continued business prosperity gives assurance of success in coal-tar products field for all byproducts with the exception of pitch which residue may carry some loss to be absorbed by the remaining products.

Record Shipments of Sulphur in Export Trade

By Raymond F. Bacon

Chemical Engineer, New York



PRODUCTION of sulphur in 1927 will probably show a substantial increase over that for 1926, and it may be expected that the total production will be somewhat less than the total shipments. Shipments indicate that the United States consumed about 50,000 tons less than in 1926; but, even so, it shows a considerable increase over 1925. The fertilizer indus-

try for the year ended July 1, 1927, sold a little over 85 per cent of the amount sold the year before; and this, together with the fact that the carry-over of acid phosphate from 1926 into 1927 was large resulted in a decrease in the consumption of sulphur.

Apprehension was felt early in 1927 as to the effect of the great capacity for pulp and paper production. However, considering the pulp and paper industry of the United States and Canada as a whole, the sale of sulphur to that industry was almost the same for 1927 as for 1926. Mills did not operate at full capacity as they had done in 1926; but, collectively, the consumption of sulphur was almost the same. It is taken as a sign of the sanity and good judgment of the industry that it has not allowed the situation to become demoralized. Hope is expressed that, by growth of consumption of pulp and paper, the large production may be absorbed and a healthy condition continue to exist in that industry.

The manufacture of acids for chemicals or for sale to consuming industries was almost the same in 1927 as for 1926. It is difficult fully to explain this situation when it is remembered that the steel industry was somewhat slack for most of 1927. One possible explanation is the treatment of larger quantities of petroleum products.

Although the sale of sulphur in 1927 only slightly exceeded that of 1926, a review can merely show that the sulphur industry, and therefore business as a whole, was satisfactory during 1927. Probably the weakest division was the fertilizer industry.

The use of pyrites has not materially increased—disregarding the copper-bearing pyrites and other sulphide ores that are converted at the mine into the sulphuric acid, as for example in the Ducktown district. California is the largest producer of pyrites in the United States. It is estimated that the imports will be slightly less than those of 1925, so that in all probability the consumption of pyrites by the United States will not be much greater than that of 1925. Imports and production in 1926 were larger than in any year since 1920.

America continues yearly to export larger quantities

of sulphur; 1927 will see exports of about 750,000 tons, the largest in the history of the American industry. This is in part due to difficulties encountered by the Sicilians in maintaining production and to the restoration of Europe to a better industrial basis. Total shipments of sulphur from Sicily in 1927 were about 240,000 long tons. Canada continues to be the largest foreign market, with France and Australasia second and third, respectively.

From all indications, 1928 should be a good year. The

fertilizer industry is proceeding with a careful program of manufacture and sales, and may be expected to consume not less than it did in 1927 and probably considerably more. The acid industry, for chemicals and for general consumption, will depend largely on general business conditions in the steel, oil and automobile industries. It is thought that these industries will be prosperous during 1928. The export market should continue at about the rate of 1927, perhaps increasing as manufacturing becomes more stable.

Production of Solvents Shows Steady Growth

By B. R. Tunison

Vice-President, American Solvents & Chemical Corporation,
New York



SOME rather unexpected developments have taken place in the solvent industries during the past year. It has been predicted by many that there would be a serious reaction to the abnormally rapid expansion of the lacquer industry as well as those solvent industries which supply it.

While a production capacity has been installed in excess of the requirements for a number of the different solvents, the demand has steadily increased for many of these materials.

The industry has been subject to fluctuations and readjustments which have resulted in keen competition which may force some of the less efficient and smaller concerns from the field. This very condition of competition and lower prices, however, has caused an expansion of the industry and its development is apparently not threatened.

It will be noted from the table that the last official tariff commission figures for the production of ethyl acetate, amyl acetate, butyl acetate and amyl alcohol show a marked increase during 1926. This increase has been due almost entirely to the requirements for the manufacture of lacquers.

PROGRESS IN THE PRODUCTION OF SOLVENTS, 1922-1926

	1922	1923	1924	1925	1926
Denatured alcohol, gal. **	33,345,748	57,565,143	67,687,296	81,808,273	105,375,886
Methanol (crude) gal. *	6,808,911	8,593,727	6,897,589	7,651,125	7,949,177
Acetone, lb.	8,742,805				
Carbon tetrachloride, lb.	11,166,318	3,513,644	14,275,057	16,163,104	18,998,848
Chloroform, lb.		1,805,083	1,301,492	1,305,868	1,909,660
Ether, lb.	4,017,043	5,104,157	5,314,928	5,355,050	5,899,681
Ethyl acetate, lb.	16,144,458	25,887,720	27,222,761	26,678,737	43,661,465
Amyl acetate, lb.	1,692,074	3,207,022	1,514,123	1,338,456	2,702,017
Butyl acetate, lb.	2,467,506	1,816,086	7,095,662	16,472,914	27,240,117
Butyl alcohol, lb.	Estimated 4,000,000	Over 4,613,396	Approx. 14,250,062		
Amyl alcohol, lb.		1,130,000		154,990	565,010

* For 11 months of 1927 the Dept. of Commerce reports an output of 7,194,633 gal. of refined methanol.

** For the fiscal year ending June 30, 1927, the output was 95,448,677 gal.

The Department of Commerce recently stated that the production of lacquers from January 1 to June 30, 1927, amounted to 14,929,000 gal. As compared with the previous six months this shows a gain of 16½ per cent. This marked increase in lacquer production will be re-

flected in the production figures for solvents for 1927.

The figures for the production of butanol are not available and estimates of it vary considerably. As a matter of fact, the estimate was made some time ago that butanol was being produced at the rate of 36,000,000 lb. per year, but more recent estimates indicate that the production is in the neighborhood of 20,000,000 lb.

During the year, some considerable progress was made in the development of other solvents, such as synthetic methanol, synthetic amyl alcohol, glycol esters, butyl propionate, etc. The production of methanol was lower than the preceding year and while for the first eleven months of 1926, the production of refined methanol was 6,870,951 gal., the production for the first eleven months of 1927 was only 4,943,185 gal. The production during October and November, however, was materially increased over preceding months and it is expected that the synthetic plants in this country will now be able to capture the market held by importers of German synthetic methanol. The increase in the tariff has assisted the domestic manufacturers in the development of the production of synthetic methanol and its substitution for the imported product. The wood chemical industries, however, are still in a very precarious position.

Probably the outstanding development of the year was the decision of the Prohibition Department to restrict and control the production of ethyl alcohol. The industrial alcohol producers have experienced a disturbing and eventful year. The production for the fiscal year ending June 30, 1927, was smaller than the preceding year and prices were unsatisfactorily low during the early part of 1927. In October a Treasury decision was promulgated which gave the Prohibition Commissioner the power to restrict and regulate the production of alcohol for industrial purposes.

Heretofore, during the early part of each year, after the demand for anti-freeze alcohol had been satisfied, there was usually a quantity of alcohol forced upon an unwilling market by producers who were unable to operate their plants at a satisfactory rate. This usually resulted in alcohol being sold to speculators and some of it found its way into questionable hands.

The Prohibition Department believes that by restricting production and controlling the quantity produced during the early part of the year, producers will not be so eager to dispose of their product to speculators and irresponsible concerns.

It is expected that some of the producers may close their plants during a part of the first six months of the year in order to carry out the wishes of the department.

The department estimates that 85,000,000 gal. will be required for industrial purposes this year and has authorized the production of that amount, not more than 40 per cent. of which may be produced during the first six months.

Large Business Transacted in Vegetable Oils

By Martin F. Austin

Manager Oil Department, W. R. Grace & Co., New York



VEGETABLE oils generally did not excite any unusual interest during 1927, with the exception of wild price fluctuations in China wood oil. Our principal domestic oil, cottonseed oil, started with a burdensome carry-over from the previous year, the visible supply at the beginning of the oil year being the largest on record. Consumption was unexpectedly large

and the market advanced rather steadily throughout the new crop growing season until the new crop figures were pretty generally understood, after which a decline occurred, as is usual during the heavy marketing movement in the fall.

Linseed Oil users were favored by an increase in domestic production of seed and a large crop in the Argentine, with heavy carry-overs from previous years. While there were flurries on the upward side, the price tendency was generally downward, and consumers had what may be called low prices.

A large business was done in coconut oil and palm oil without startling price fluctuations. The same might be said of olive oil foots although the quantities of this article seem to becoming a little less each year with new refining processes enabling producers to manufacture a second grade of edible oil, thus reducing the quantity of foots.

In rapeseed oil, about the usual volume of business was done, with minor price fluctuations, consumers being favored by satisfactory price levels throughout the year. This market has remained in the hands of the Japanese sellers the last year or two. At present the difficulties in getting seed from China do not give much assurance for the coming year. Should they continue, higher prices may be expected because European production goes so largely into edible channels, thus raising the cost for industrial users.

On soya bean oil, the prohibitive duty of 2½c. per lb. excluded any great volume of imported oil and domestic production does not seem to be stimulated beyond the comparatively small quantities produced in the last few years.

For China Wood Oil, we have seen the most startling price changes ever known. Starting in January with prices varying from 10½c. to 12c. per lb., according to shipment, the market advanced to 29c. per lb., with a decided premium on the earlier shipments; an irregular decline occurred throughout the summer till the level of 12c. per lb. was reached in October, followed in the last few weeks, by another advance, on conditions reported similar to last year. At this writing, reports from China are that great difficulty will be experienced in getting China wood oil especially, and other China produce generally, from that country.

The writer considers there are two lessons to be gained from the current year's business in vegetable oils: First, the necessity to recognize that fats and oils, as a whole,

must be regarded from a world wide supply and demand standpoint, and that the unwisdom of our tariff barrier has again been borne out by the relatively small exports of cottonseed oil, and an almost complete cessation of imports of competitive oils, with no advantage to the producers of domestic cottonseed oil, or the growers of the seed, and a decided disadvantage to the American oil establishments which have lost a very tangible and definite volume of profitable business without offsetting advantages to anyone in this country. In other words, we have given our European customers, who are necessarily buyers and cannot produce any of these oils, an opportunity to dictate the price they will pay the world's producers for the fats and oils of which they are continuously in need. The second lesson which we would deduct from this year's business is the advisability of consumers contracting far ahead for their requirements on staple or necessary oils when this opportunity offers at reasonably low prices. Had this practice been pursued in China wood oil, each individual manufacturer would have saved many thousands of dollars, and placed the importer and shipper in position to contract equally far ahead, and thus possibly have avoided the wild price fluctuation which usually occurs following sudden impulse, gained from startling reports. While this occurred only in China wood oil this year, it has occurred in other oils in past year. The lesson loses none of its force from one year to another.

Inter-Industry Competition in Nitrogen

By R. S. McBride

Assistant Editor, Chem. & Met.



DESPITE a reduction in the number of plants for synthetic ammonia production in the United States the output of this branch of the industry increased by 45 per cent over the preceding year. In other countries the increase was even more startling in tonnage, although not as great in percentage of previous production. At the end of the year there were oper-

ating in the United States only six direct synthetic ammonia plants, and three of these were contributing about 95 per cent of the total production, the other three being, therefore, almost a negligible factor in the industry. Two other small plants were idle at the end of the year.

In practically all cases the ammonia synthesis processes remained unchanged fundamentally, except in the case of one plant which made radical modification in its methods for generating hydrogen from blue water gas. The Commercial Solvents Company plant was, however, converted from an ammonia plant to a methanol plant after a very brief trial to demonstrate its practicability for the former function. This reduced the number of existing plants from nine to eight, but the number will probably be again increased to nine during 1928 by the completion at Hopewell, Va., of the first unit of the plant of the Atmospheric Nitrogen Corporation.

THE ownership of several of the plants changed during the year, partly for patent reasons. At the close of 1927 the industry is found concentrated essentially into three groups, owned respectively by the Atmospheric Nitrogen Corporation, Lazote, and Mathieson Alkali Works. It is natural that the Atmospheric Nitrogen Corporation should strive for a dominating position in this field, because it is owned by the Allied Chemical and Dye Corporation, which has other subsidiaries which have for a long period been either important producers or users or dealers in ammonia. The Barrett Company has long been the principal merchandizing agent for ammonium sulphate and the Solvay Process Company is one of the outstanding users of the ammonia-soda process, a substantial consumer of ammonia. As a matter of fact, the Atmospheric Nitrogen Corporation itself is a successor to the General Chemical Company, still another member of this industrial family, specializing in the nitrogen production which was initiated as a part of the General Chemical Company's business.

Similarly Lazote, a du Pont subsidiary, represents the point of view of a parent company with large interest in the consumption of nitrogen chemicals. For its work in explosives manufacture this concern and its affiliated and subsidiary corporations is one of the principal users of both ammonia nitrogen and nitrate nitrogen. By its more recent acquisition of the National Ammonia Company it has come to have also an important interest in the marketing of aqua, anhydrous and other industrial forms.

Practically all the other synthetic ammonia producers have been, and still are, concerned with ammonia simply as a means for efficient utilization of hydrogen obtained a byproduct of alkali manufacture or other industrial chemical business. The Mathieson Alkali Works, Roessler and Hasslacher, the Belle Alkali Works, and several small producers have all been in this class. They will, of course, be able to continue production up to the quantity of byproduct hydrogen available, but it is unlikely that any one, or all of them together, will ever become dominating factors in the general ammonia situation on such a basis. Large increases in output will necessitate manufacture of hydrogen, either from water gas, coke-oven gas, or other independent source, in order to make ammonia manufacture independent of caustic or other electrochemical production.

PRODUCTION of ammonia as a byproduct of coal processing continued along conventional lines without any noteworthy technologic developments during the year. A slightly reduced output of byproduct ammonia was a normal result of the slightly curtailed demand for byproduct coke.

Imports of Chilean nitrate continued at a low level because of the continued sluggish market for all classes of fertilizer materials. There is some evidence that the curtailment in the nitrate market will continue due to several factors. Among these are a movement of cotton acreage from the southeastern states to the southern states west of the Mississippi River where less fertilizer is used; a substitution of ammonia oxidation units for the niter pots, both in manufacture of nitric acid and in the manufacture of nitrogen oxides for sulphuric acid plants; and, perhaps most important of all, a growing appreciation among agriculturists of the fact that ammonium sulphate is worth more per pound because of its higher nitrogen content than is Chilean nitrate, for practically all combinations of crops, soils and climates. This last

factor is tending very definitely toward the replacement of Chilean nitrate fertilization by ammonium sulphate fertilization, both in mixed fertilizers and for separate use as a top dressing or side dressing on high-value crops. During the past year, however, Chilean nitrate has maintained throughout the world an advantage of 20 to 25 per cent higher price per pound of nitrogen contained than ammonium sulphate.

The controversy over probable price trends in the nitrogen markets continues to center around a discussion of possible changes in the cost of Chilean nitrate delivered at United States eastern seaboard ports. Although the new processes applied by American producers in Chile have resulted in substantially lowering the costs the very great advantages forecast have apparently not been fully realized. It has, however, been demonstrated that the price of Chilean nitrate f.a.s. New York can go lower than it seemed likely four years ago when Bain made his widely quoted report on this subject. Those thoroughly conversant with conditions in Chile state that complete extinction of the industry, forecast by Bain at \$28 per ton, probably would not occur until the New York price reached a much lower figure.

Among the improvements and changes that may permit work at this low price are suggested the following: (1) Shading to the point of removal of the Chilean export tax; (2) annulment of unreasonable labor laws; (3) reduction in mining and sorting expense by the treatment of the immense reserves of nitrate in the residue from older and extremely inefficient processing methods; (4) simplification and cheapening of treatment of raw material; (5) reduction in material- and product-handling costs; (6) increase in recovery of nitrate from raw material and decrease in time of treatment; (7) production of a high-quality product, and (8) shipment in bulk instead of in bags.

The possibility of making iodine a more profitable byproduct is also suggested as a possibility; but this cannot be counted on as largely as the other factors, since success in this direction must assume that with large production and lowering of price there will develop large new industrial requirements for iodine.

CERTAIN important technologic factors which similarly control the probable future prices for byproduct ammonia, particularly ammonium sulphate, have often been seriously neglected; but they are now beginning to be fully appreciated both in the coke and gas industries and in the competing nitrogen producing groups. When coal is coked, ammonia is inevitably formed. This ammonia in the crude gas must be removed before the gas can be used for industrial heating or for city-gas supply. And when it is removed, either as ammonia liquor or in ammonium sulphate, it is not practicable to throw it away, because if the ammonia is discharged into a stream it is detrimental to fish life and hence the public authorities sharply limit such waste-disposal practice.

Under these conditions the quantity of ammonium sulphate which must be marketed in some fashion is more or less directly controlled by the coke and gas requirements of the country. Hence the coke and gas producer having ammonia for disposal is going to offer this at as low a price as may be necessary in order to secure reasonably prompt markets. It is variously estimated how low the price of ammonium sulphate could become before the present byproduct credit which results from its sale would be converted into a waste-disposal cost. In

general these estimates indicate that so long as ammonium sulphate is marketable at \$20 per ton f.o.b. producers works it will not be an actual cost-creating element in the business.

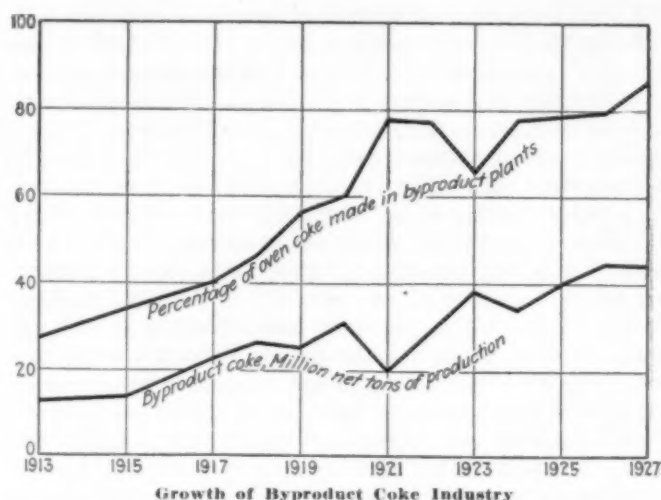
In the past ammonium sulphate and Chilean nitrate have been sold at about the same price per ton, despite the fact that ammonium sulphate contains a third more nitrogen. Growing appreciation of the equality in the fertilizing value of these two chemicals per pound of nitrogen contained will probably materially reduce the spread in price per unit of nitrogen and thus increase the price spread per pound of chemical. It appears that one can expect a continued marketing of ammonium sulphate up to the producing capacity of the country at even lower price ranges than can be tolerated by even the most efficient probable developments in the Chilean nitrate business.

In effect this means that ammonium sulphate up to the quantity which must be produced by coke and gas plants will be marketed and only the excess in the country's requirements above this figure can hope to be supplied by other nitrogen carriers. This means that the real competition of the future and the real price fixing of the future will be determined by the competitive relation between synthetic products and Chilean nitrate, ammonium sulphate getting its base-load business and the other two commodities fighting for the remaining market.

The best available present estimates indicate that modern plants can manufacture ammonia by the direct synthetic process at not less than 6c. to 7c. per lb. of ammonia, assuming that the hydrogen is made from either water gas or by electrolysis. These costs f.o.b. producing works provide a product much better suited for refrigeration, ammonia, oxidation, and certain other industrial chemical uses than is the liquor made at gas or coke works. Hence it is likely that this synthetic ammonia, which is produced under pressure in anhydrous form, will continue to monopolize the markets for refrigeration and like uses where anhydrous or high purity ammonia is wanted. The question thus becomes one of determining at what cost synthetic ammonia would enter the fertilizer nitrogen market.

It is probable that the cost of converting ammonia, whether from cyanamide or direct synthetic process, into a marketable fertilizer product is not less than \$10 per ton of fertilizer salt. This means that the finished fertilizer chemical will cost \$30 per ton of 20 per cent nitrogen material if ammonia is 4c. a lb., or \$40 per ton if the ammonia is 6c. a lb. Let us suppose, therefore, that a concern estimates that it can make synthetic ammonia at 6c. a lb. and wishes to market this product in competition with ammonium sulphate at the present price f.o.b. producers' works, which is about \$40 per ton. This could perhaps be done if the conversion from the ammonia to ammonium sulphate could be carried out at low cost for acid, low investment cost, and with a nominal selling expense. There would be, obviously, a very narrow margin of profit in any such undertaking.

Moreover, the producer of synthetic ammonia for fertilizer must face the fact that he cannot hope to get this \$40 per ton of 20 per cent nitrogen product for long if he produces a surplus of fertilizer nitrogen chemical above the current market requirements. Both the Chilean nitrate producer and the ammonium sulphate producer can readily cut the market price below that prevailing at present. Both can undoubtedly lower it to a point where synthetic ammonia would have to be



less than 4c. per lb. in order to begin to drive the other commodities from the market. And even then, the question would be—What is to be the attitude of the Chilean government? If that government should suddenly remove entirely the present export tax this would at once cut between \$10 and \$12 per ton from the cost c.i.f. New York.

THIS general discussion of the interlocking of technologic and economic factors shows why there is at the present time no use of domestic atmospheric nitrogen made by the direct synthetic process for fertilizer purposes. The only synthetic nitrogen products being used in fertilizers in the United States are cyanamide, used as such up to 40 or 50 lb. per ton of mixed fertilizer, and the imported ammonium sulphate or ammonium sulphate-nitrate. These latter two chemicals represent largely an ammonia production in Germany in excess of that country's requirement. The American producer must, therefore, not only improve his technology to the point of successfully competing with the Chilean nitrate producer, but he must also anticipate a very severe competition from the synthetic nitrogen plants of Europe which for some time to come give promise of a serious threat in the United States nitrogen markets. Until the technology of nitrogen fixation in the United States advances to this point, the market for this product is likely to be largely in the field of explosives, sulphuric acid manufacture, rayon production, refrigeration, and like uses where the anhydrous or high-purity product is essential.

Fortunately these industrial chemical uses of ammonia have been greatly stimulated, particularly during the past year. There has been a conspicuous growth in the extent of ammonia oxidation, both for nitric acid manufacture and for the manufacture of nitrogen oxides to be used in sulphuric acid making. At the end of 1927 ammonia was being oxidized for these two branches of the acid industry at a rate probably exceeding 3,500 tons of ammonia per year. It is reliably reported that the present rate of ammonia oxidation for nitric acid manufacture will be doubled, or even trebled, during 1928, and the number of plants using ammonia oxidation for sulphuric acid making is increasing monthly.

This increase in use of ammonia is, of course, altogether a result of substitution of ammonia oxidation for niter-pot operation. Thus synthetic ammonia finds a further outlet at the expense of Chilean nitrate—and the end of this trend is not yet in sight.

Byproduct Coking Maintained Despite Slower Demand

Editorial Staff Review

CURTAILMENT in the demand for steel during 1927, occasioned a corresponding reduction in the requirement for coke; but byproduct coke production decreased by only about one per cent as most of the reduction in tonnage was accomplished by curtailment of beehive-oven activity to 57 per cent of the production of 1926. Thus the year afforded another proof that the beehive-oven division of the industry is now merely a balance wheel, stabilizing coke supplies in accordance with current requirements, and that the byproduct division is a base-load business which continues largely independent of the total metallurgical demand.

The slackening in coke production which occurred near the close of 1926 continued almost without interruption during 1927 in the beehive division, except for a slight renewal of activity during February and March. The rate of production of beehive coke at the end of the year was less than half that at the beginning. The rate of production in the byproduct division of the industry increased slightly during the first three months of 1927, but has fallen slightly since March, reaching a low point in November only 7 per cent below the peak rate of production. During 1927 byproduct coke constituted 86 per cent of oven coke production, a record percentage for all time.

THE COAL processed in gas retorts and in byproduct ovens combined was approximately the same in 1927 as during the preceding year, the increase in produc-

tion at gas works almost exactly offsetting the slight decrease in activity at byproduct coke plants. Not only was more coal processed in gas retorts during 1927 than in any preceding year, but also there was an increase in the use of gas from byproduct ovens for city supply above any preceding record. The effect of greater participation of public-utility gas companies in the business of coking has apparently given a distinctly stabilizing effect upon the rates of production of all coal products.

The community of interest between the coke and the gas industry is still further evidenced by the slow, but definite, trend toward greater percentage of byproduct coke production at merchant plants. The percentage of byproduct coke made at works connected with blast-furnace establishments is a decreasing part of the total, although the total capacity of such works has increased every year and the output in most years since the world war. The growth in byproduct oven use has been more rapid at establishments not directly connected with blast furnaces. At the end of 1927 approximately 26 per cent of the byproduct coke being produced was being made at merchant plants, and 80 per cent at furnace plants.

On January 1, 1928, there were in existence or very nearly completed for operation approximately 12,860 byproduct coke ovens. This represents an increase during the year of over 1,100 ovens, or approximately 10 per cent. Present indications are that there will be a substantial, but somewhat smaller percentage, increase in the number of ovens during 1928.

THE RATED annual capacity of byproduct ovens at the end of 1927 was approximately 81 million net tons of coal, equivalent to 56 million tons of byproduct coke per year. The rate of production at the end of the year was approximately equal to 75 per cent of the aggregate rated capacity of completed ovens, but a slightly smaller percentage than this if one includes the capacity of the ovens nearing completion but not yet in operation on December 31. A year ago the rated capacity of the installations was 72 million tons of coal, equivalent to 50,500,000 tons of coke per year; and at that time the ovens were operating on the average at 92 per cent of capacity. The large reduction in percentage of capacity operation is obviously occasioned much more by increase in available capacity than by actual decrease in rate of production; but the actual daily rate of production at byproduct plants at the end of 1927 was about 6 per cent below the daily tonnage rate twelve months ago.

Gross production, yields, value, and character of usage of gas, tar, light oil, and ammonium sulphate are given statistically in the accompanying tables. It is of interest to know the extent to which these coal products are now being used or refined by the original producers. Of the total oven tar production 48 per cent is so employed, 250 million gallons for metallurgical furnace fuel and about 8 million gallons for boiler fuel. The percentage of the total byproduct oven gas which is required for heating the ovens has decreased largely during recent years. Of the gross production in 1926, the last year for which complete figures are available, 41.9 per cent was burned for heating the ovens, 1.8 per cent was wasted because of lack of immediate and accessible market, and 46.3 per cent was sold. About 97 per cent of the crude light oil removed from oven gas was refined by the producer, yielding marketed derivatives aggregating 81 per cent of the crude light oil refined; and of these derivatives motor benzol constituted 70 per cent.

The Coal Products Industry

Data for 1926 from U. S. Bureau of Mines; estimates for 1927 by
Chemical & Metallurgical Engineering

	1926	1927
Coal processed (million net tons):		
Beehive coke ovens.....	19.2	10.7
By-product coke ovens.....	63.6	62.8
Coal-gas retorts.....	.....	7.2
Total.....	.....	80.7
Coke produced (million net tons):		
Beehive coke.....	12.5	7.0
By-product coke.....	44.4	43.8
Oven coke breeze.....	4.4	4.0
Retort coke.....	.....	4.2
Total.....	.....	59.0
Gas produced (billion cu. ft.):		
Coke-oven gas.....	707	700
Retort coal gas.....	.....	72
Other manufactured gas.....	.....	303
Natural gas (marketed).....	1320	1450
Total.....	.....	2525
Tar produced in coke ovens (million gal.).....	530	525
Crude light oil produced (million gal.).....	164	162
Ammonia produced, total sulphate equivalent (thousand net tons).....	691	688
Naphthalene produced (million lb.).....	7.9	7.0

Coke and By-product Yields and Values in 1926

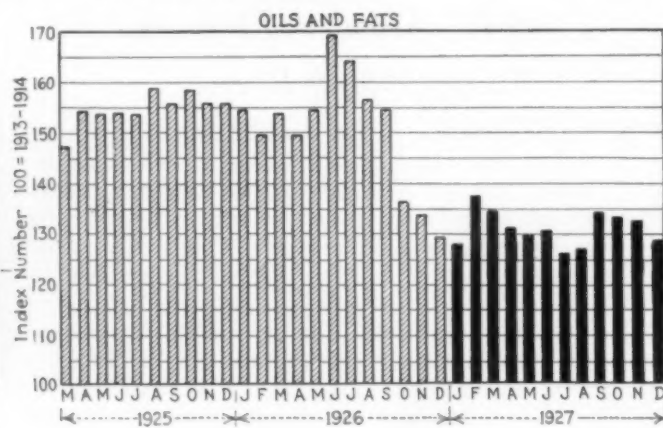
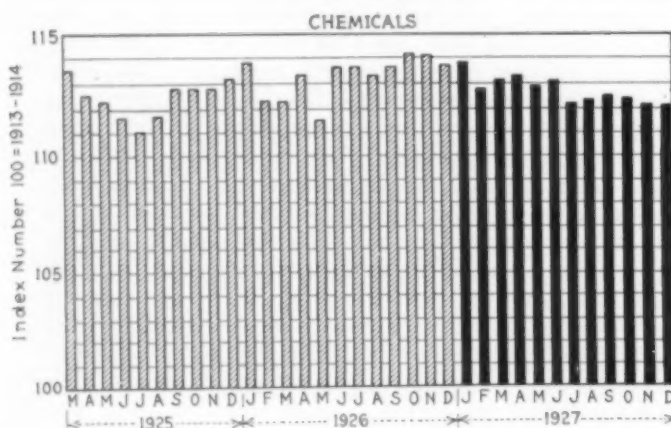
(Data from U. S. Bureau of Mines)

	Yield per ton of coal treated	Value, F.o.b. works, per unit sold	Value per ton of coke made
Coke.....	1,394 lbs.	\$6.95 per ton *	\$5.65
Screenings and breeze.....	131 lbs.	\$3.50 per ton *	0.21
Tar.....	8.3 gal.	5.1¢ per gal.	0.61
Ammonium Sulphate or equivalent.....	21.7 lbs.	2.1¢ per gal.	0.63
Crude light oil.....	2.8 gal. †	12.3¢ per gal. }	0.62
Light oil derivatives.....	.....	20.8¢ per gal. }	.....
Gas, total.....	11.1 M cu. ft.	.....	.....
Gas, surplus.....	6.3 M cu. ft.	16.3¢ per M ‡	1.46
Total value of coke and by-products.....	.....	.....	\$9.18

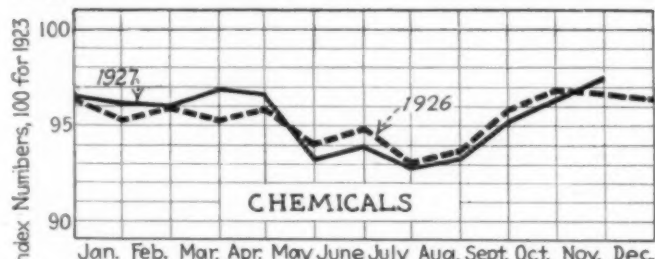
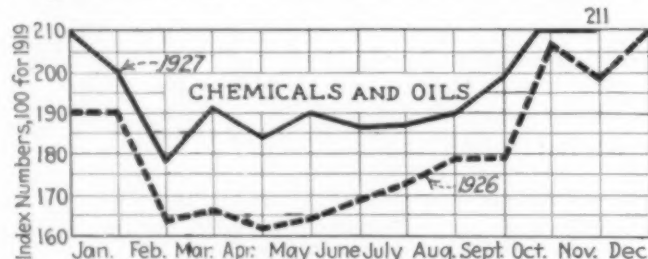
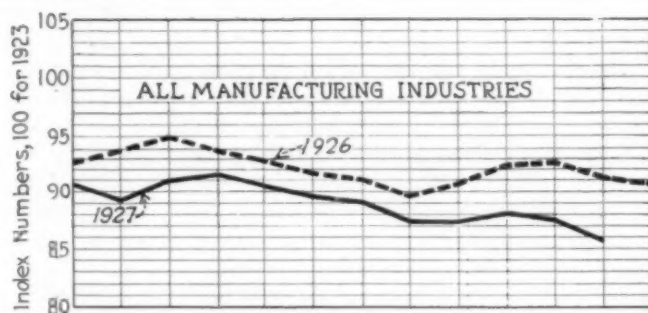
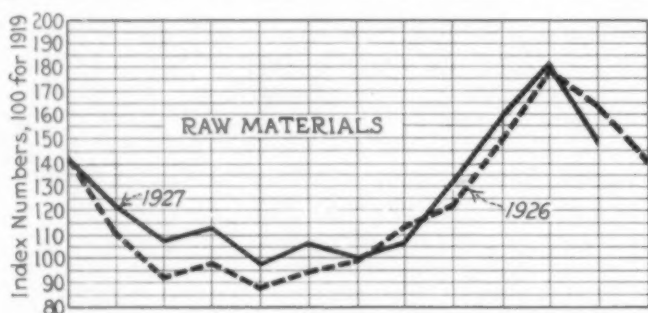
* Values for coke and breeze per ton are for both coke sales and coke used by producer.

† Average for plants recovering light oil.

‡ The sales price for gas varied widely according to the purpose for which it was sold, as follows: Used under boilers 5.5 cents per M, used in steel and related plants 11.2 cents per M, used for industrial purposes 16.3 cents per M, and sold for distribution through city mains 33.6 cents per M.

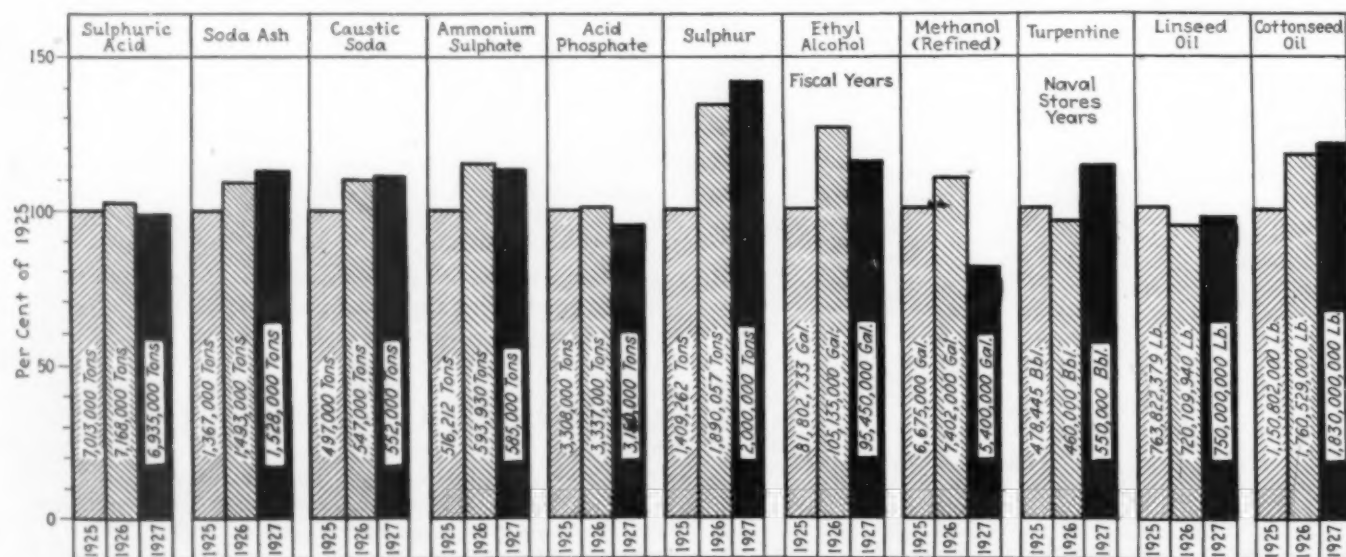
CHEM. & MET. *Weighted Indexes of PRICES*

CHEMICAL INDUSTRY IN 1927



VOLUME OF PRODUCTION
(U.S. Department of Commerce)

FACTORY EMPLOYMENT
(U.S. Bureau of Labor Statistics)

CHEM. & MET. *Estimates of PRODUCTION of BASIC CHEMICALS*

Lower Average Prices for Chemicals

Weighted Index Number Shows Slight Decline for the Year

DOMESTIC production of chemicals was maintained on a high scale throughout 1927 but, for the industry as a whole, the output was slightly lower than in 1926. The rate of chemical production is influenced by that for general industry but as conditions vary in the different consuming trades it follows that demand for chemicals is not uniformly affected by changes in industrial activity. This accounts for the fact that estimates give chemical production for last year at 3 per cent to 5 per cent below the total for 1926 whereas different chemicals, including such important selections as soda ash and caustic soda, were turned out in larger volume.

Large consumers are adhering to the policy of covering requirements by contract placements and this brought about a fairly even distribution throughout the year. Contract buying was on a large scale in the latter part of the year and producers, especially of the more important chemicals entered the new year with a good part of their 1928 production sold ahead. Unsold stocks were large in some selections at various times and had a weakening effect on the spot market but in general production was regulated so as to avoid congestion.

AS A rule price fluctuations were within narrow limits and the even tenor of values was one of the features to trading. Sulphuric acid, the most important chemical from a tonnage standpoint was firmly held because producers were working on higher priced sulphur and this situa-

tion promises to continue with any change in acid prices favoring an advance. Lower prices prevailed for soda ash and caustic soda and the general average of prices was lower than in the preceding year. *Chem. & Met.*'s weighted index number for chemicals was 113.76 in January and 112.08 in December. The average weighted number for the year was 112.74 as against 113.26 for 1926. The lower level of prices seems to be due largely to improved technique, greater mechanization of plants with corresponding increase in output per worker, and to the increased output which has enabled plants in the last few years to operate more closely to capacity. Prices for finished products also have been affected by the lower values for raw materials with competition keen enough to establish sales prices in close proximity to production costs.

THE most important development in the market from the tariff standpoint was the reduction in duty on refined cresylic acid. Late in July, the President announced a decrease in the duty on this chemical from 40 per cent ad valorem upon the basis of the American selling price as defined in the Tariff act, and 7c. per lb., to 20 per cent ad valorem and 3½c. per lb. This reduction was the maximum possible under the flexible provisions of the Tariff act. Increased protection through higher import duties also was sought in the case of other chemicals. The report on barium carbonate was completed before the end of the year and will be sent to the President early in 1928. Investigations into production costs were completed for tartaric acid and cream of tartar. Because France is a competitor in cream of tartar, further action was delayed pending the recent tariff conference between this country and France and it is possible that work will be taken up separately on tartaric acid. Large imports of permanganate of potash were responsible for the petition for higher duty on that chemical. Invest-

tigations were made and hearings held and a similar situation is reported for sodium silico-fluoride. Keen competition from Belgium was the influence which brought out the petition for a 50 per cent tariff rise on whiting and precipitated chalk. This case, by the end of the year, had not passed the stage of ascertaining production costs. In the same position is the case involving sodium phosphate in which foreign producers were giving considerable competition, especially in the di salt. The investigation, however, includes the mono and tri salts. The linseed oil case has dragged on with no indication of an immediate decision.

EXPORT trade in chemicals and related products for the eleven months ended November were valued at \$120,589,924 as compared with \$113,337,417 in the corresponding period of 1926. As the average unit price was lower in 1927 it becomes evident that the increase in volume of exports was greater than is indicated by the comparison of values. The formation of a cartel comprising the English, French, German, and other European producers is regarded as a threat to future development of our export trade but competition in foreign markets has been very keen in recent years and this condition may not be affected materially by any action of foreign producers. Import trade in chemicals and related products for the first eleven months of 1927 was represented by a valuation of \$119,497,505 which compares with \$124,691,320 for the corresponding time in 1926.

Chem. & Met. Weighted Index of Chemical Prices

Base = 100 for 1913-14

This month	112.25
Last month	112.08
January, 1927	112.79
January, 1926	113.86

Price changes were reported on both sides of the market but the net result favored a slightly higher average. Ammonia salts retained a firm position and higher sales prices went into effect for acetone and copper sulphate.

Chem. & Met. Weighted Index of Prices for Oils and Fats

Base = 100 for 1913-14

This month	129.76
Last month	128.30
January, 1927	127.35
January, 1926	154.79

Sharp rises in values for China wood oil combined with higher markets for linseed oil and tallow more than counterbalanced a decline in crude cottonseed oil and the weighted index number was higher for the month.

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Acetate of Lime..... 63	Caustic Potash 60	Cream of Tartar..... 63	Silicate of Soda..... 61
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Bichromate of Soda Held Steady Course

BICHROMATE of soda was held an even keel throughout the year both in respect to prices and tonnage. Open quotations for round lots showed very little range during the period but contract prices showed some variation with the largest buyers securing the most advantageous prices. Production costs were practically on a line with those for the preceding year with chrome ore steady and lower prices for soda ash counterbalanced by strength in sulphuric acid. The tonnage likewise was about on a par with 1926, plants being operated practically at capacity. Total production is estimated at 26,000 tons. Improved call for bichromate came from the leather trade with textile manufacturers and dry color makers following as the next largest consumers. Gains in export shipments also were made with shipments of chromate and bichromate for the first eleven months of 1927 totaling 7,902,670 lb. valued at \$501,030. Exports of chromate and bichromate in 1926 and 1925 were 8,526,936 lb. and 7,299,336 lb. respectively.

Imports of chrome ore for the first eleven months of the year were 214,944 tons valued at \$1,711,347 as compared with 149,739 tons valued at \$1,207,420 in the corresponding period of 1926. Of total imports it is estimated that 13 per cent was taken by the chemical trade with the steel and refractory industries taking up the greater part of the remainder. Rhodesian ore predominated in our import trade.

Bichromate of potash has made little headway toward regaining its tonnage of former years and most consuming industries give the preference to the soda product.

Copper Sulphate Meets With Active Demand

CENSUS compilations credit domestic production of copper sulphate in 1925 as amounting to 32,296,583 lb. valued at \$1,683,788. For the same year copper smelters and refiners reported an output of copper sulphate valued at \$1,019,191. Domestic consumers of copper sulphate were active during the year and sales were reported to have been larger than in 1926 with a corresponding effect on production. Imports of sulphate for the eleven months ended November were 1,587,326 lb. valued at \$70,541 as against 2,414,387 lb. valued at \$111,339 in the corresponding period of 1926. Exports in the same interval were 5,301,320 lb. valued at \$275,790 and 4,501,188 lb. valued at \$216,044 in the eleven-month

period of 1926. Hence the foreign trade account in copper sulphate is in favor of the home product. In fact the freedom from foreign competition has been a feature of the sulphate market in contrast with the situation a few years ago when importations were large and prices were under pressure. In the export trade, it is also noted that higher prices were obtained in 1927 and while this undoubtedly was due to higher intrinsic values based on producing costs, it also would appear that world producers are restricting their efforts to certain countries and are avoiding, as much as possible, direct competition where it would lead to a sacrifice of values.

With selling pressure less in evidence, prices for copper sulphate last year followed in close harmony with fluctuations in the metal. The trend of values was upward and the market closed the year in a very strong position.

Domestic Nitrite of Soda Controls Market

IN MAY, 1924, the import duty on nitrite of soda was increased from 3c. to 4½c. per lb. This action has had a decided influence on domestic markets since that time. At the time the higher import duty was promulgated domestic production was at a standstill and the greater part of domestic requirements were filled by importations, chiefly from Norway and Germany. With the

greater protection afforded by the increase in duty, domestic plants again took up the manufacture of nitrite and foreign shippers gradually began to offer less competition. Arrivals from abroad in 1925 and 1926 were relatively light but domestic control of the market was emphasized last year when importations of nitrite were recorded as 252,860 lb. valued at \$9,376.

As demand for nitrite of soda is increasing and imports are negligible it is logical to look for an expanding home production. This chemical is not listed in the census returns and official figures for domestic production are not available. Current requirements of this country are now estimated at approximately 9,000,000 lb. and this figure should be fairly representative of domestic production last year. The dye industry holds its place as the principal consumer. Considerable reliance had been placed in an extensive market for nitrite of soda throughout 1927, in the meat packing field and while sales in that direction showed an increase, it was far from expectations and had but little influence in extending production.

The price trend for nitrite of soda was downward throughout the year and while the competition was confined to domestic producers, the lower levels reached are unfavorable for any resumption of import business. Toward the close of the year large consumers were able to contract for 1928 deliveries at very attractive prices and producers entered the new year with a large part of their future output sold ahead.

Synthetic Methanol Offered in Larger Volume

AMONG the most important developments of the year in the market for methanol, was the introduction of domestic synthetic methanol on a commercial scale. The synthetic product had been a disturbing factor for some time but until last year, it was of German origin. With domestic production established, the output of refined metha-

nol on the part of wood distillation producers was curtailed although there was not much change in their output of crude methanol as compared with 1926.

Synthetic methanol with its accompanying competition also was important as a price factor and the low levels reached in 1926 were continued over a good part of 1927 and later were succeeded by still lower quotations with the decline in values said to be based on production costs.

PRODUCTION OF METHANOL

	Production At Plants	Crude Stocks, End of Month At Refineries and In Transit	Production At Plants	Refined Shipments or Con- sumption	Stocks, End of Month
1926					
November.....	720,798	463,049	144,136	623,544	331,256
Total (11 months).....	7,362,275			6,870,951	
1927					
January.....	805,473	397,999	341,444	480,448	436,656
February.....	680,583	40,847	613,939	305,479	426,736
March.....	726,694	387,684	645,852	569,059	597,379
April.....	666,638	325,888	819,216	420,741	606,975
May.....	638,376	345,366	896,334	426,304	554,313
June.....	626,789	359,632	991,672	416,042	521,609
July.....	592,593	*301,812	1,094,775	347,833	554,809
August.....	582,710	*367,657	1,408,637	317,521	428,194
September.....	576,947	*320,231	1,467,460	441,771	382,876
October.....	643,491	*375,965	1,181,225	688,435	396,137
November.....	654,339	365,584	1,407,745	529,552	452,246
Total (11 months).....	7,194,633			4,943,185	4,983,809

Sulphuric Acid Holds Strong Price Level

PRODUCTION of sulphuric acid was somewhat lower in 1927 than in 1926. Fertilizer manufacturers, which industry is the largest consumer of sulphuric acid, restricted operations materially in the first half of the year and although they reported enlarged outputs in the latter part of the period, they failed to equal their 1926 tonnage. Consequently consumption of acid was cut down correspondingly. Varying conditions were found in other lines which consume sulphuric acid but net changes were in favor of smaller total consumption.

Very little change was noted in the use of raw materials for acid manufacture. An increase in domestic production of pyrites was offset by a decline in importations. Sulphur, therefore, maintained its position as the principal raw material. In 1925, sulphuric acid to the value of \$3,734,126 was made at zinc smelters and to the value of \$444,558 at copper smelters and trade estimates place acid production from those sources as having varied but little in the last two years.

With sulphur as the most important raw material in sulphuric acid manufacture, the firm position of the ore has given a strong undertone to acid prices and higher levels are predicted in trade circles.

Foreign trade in sulphur acid is unimportant and within the domestic trade new outlets have been slow to develop. Hence total sales of acid last year were influenced by the state of activity in

Sulphuric Acid in 1927 Chem & Met.'s Annual Estimates of Production and Distribution (In tons of 50° Bi. Acid)

Industry	(Revised) 1926	1927
Fertilizer manufacture.....	2,059,000	1,925,000
Petroleum refining.....	1,325,000	1,350,000
Chemicals.....	750,000	725,000
Coal products.....	742,000	732,000
Iron and steel.....	740,000	685,000
Other metallurgical.....	725,000	700,000
Paints and pigments.....	200,000	210,000
Explosives.....	190,000	183,000
Textiles.....	120,000	135,000
Miscellaneous.....	317,000	290,000
Total.....	7,168,000	6,935,000

old consuming lines. With such large buyers as the fertilizer, chemical and iron and steel trades restricting purchases it was inevitable that sales should fall behind those for the preceding year, the loss amounting to approximately 233,000 tons.

Stocks of Calcium Arsenate Increased Last Year

NINETEEN companies or firms, operating 22 plants, reported for the year ended August 31, 1927, the production of 18,715,563 lb. of calcium

arsenate, 18,728,054 lb. of lead arsenate and 5,743,048 lb. of Paris green. For the year ended June 30, 1926, 21 companies reported the production of 5,363,320 lb. of calcium arsenate, 16,898,214 lb. of lead arsenate and 2,863,691 lb. of Paris green, according to the Department of Commerce. The increase in production merely served to add to unsold stocks.

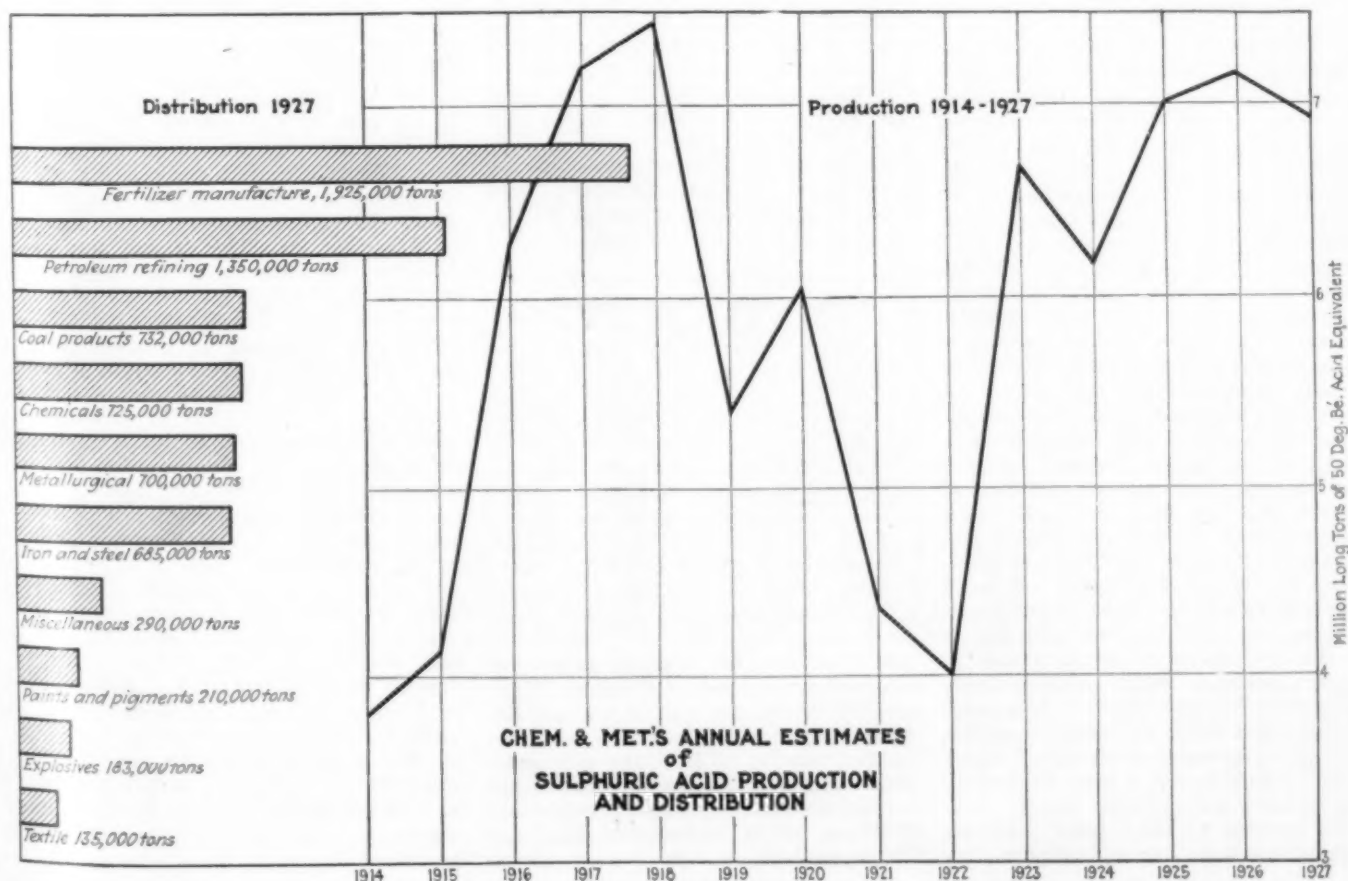
No reports were received from three companies which, according to the bureau's records, are engaged in the manufacture of insecticides. No close estimate is possible, but it is roughly estimated that the figures given in the statement below represents not less than two-thirds of the total production of insecticides in the United States.

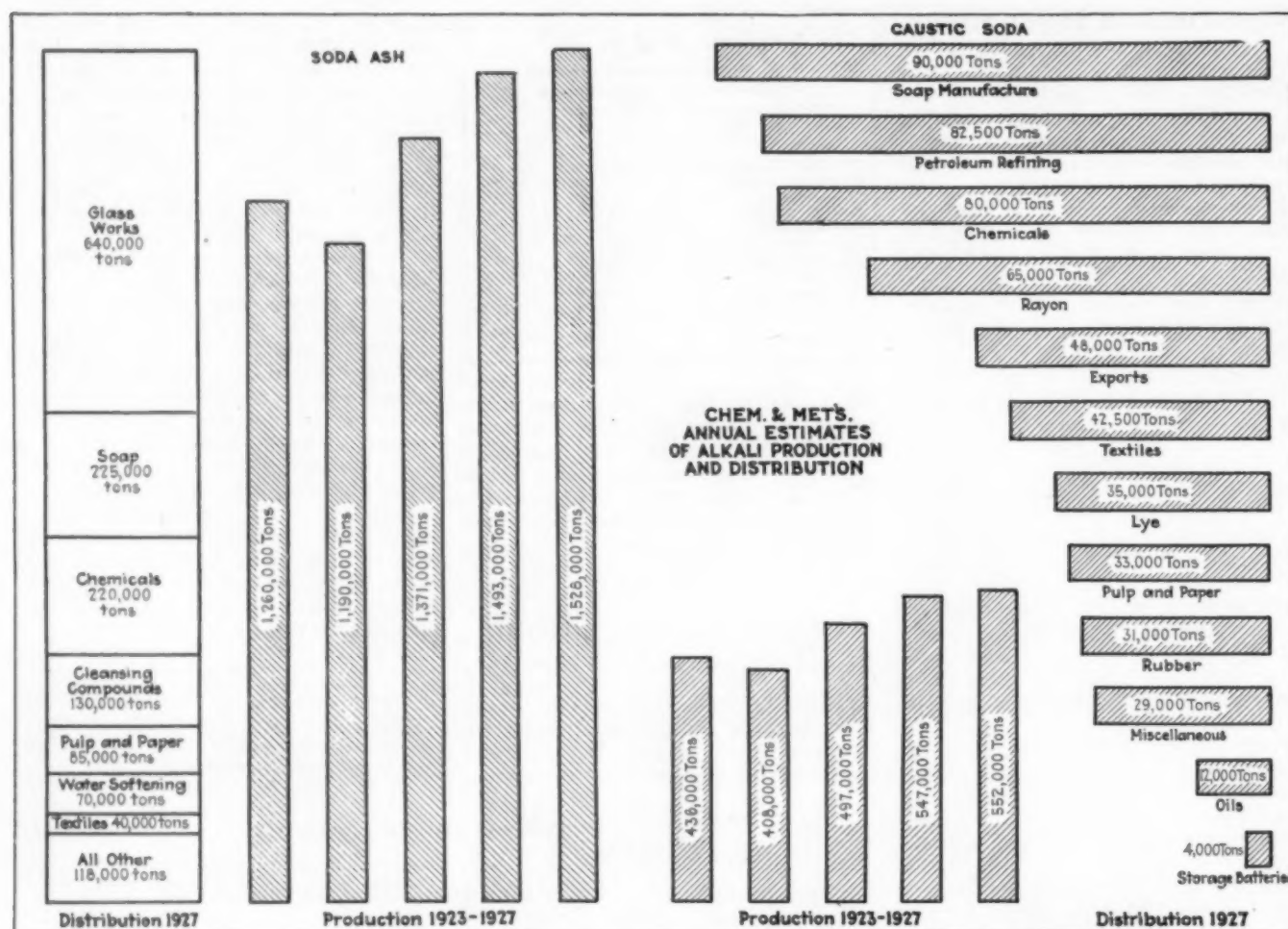
The following statement shows the production and sales during the years ended August 31, 1927, and June 30, 1926; stocks on hand at the end of the year, quantity of arsenic consumed and on hand at the end of the year, and amount contracted for use during the following year:

Distribution of Arsenic			
Used in the manufacture of	1927, Lb.	1926, Lb.	
Calcium arsenate.....	7,021,219	2,111,782	
Lead arsenate.....	5,153,103	5,384,193	
Paris green.....	4,195,693	2,255,069	
On hand at end of year....	3,760,655	3,320,348	
Contracted for use during the following year.....	2,731,993	1,638,000	

Production of Arsenicals 1926-27

	Production and Stocks		Stocks on Hand	
	Year Ended Aug. 31, 1927, Lb.	June 30, 1926, Lb.	Aug. 31, 1927, Lb.	June 30, 1926, Lb.
Calcium arsenate.....	18,715,563	5,363,320	11,632,910	6,172,446
Lead arsenate—Powder.....	18,359,122	16,573,784	3,660,429	1,981,133
Paste.....	368,932	324,430	26,034	13,400
Paris green.....	5,743,048	2,863,691	1,829,247	1,164,297





Increased Sales Reported for Soda Ash

ANOTHER year of expansion is reported in the soda ash trade with the total volume passing to consumers exceeding that for 1926 which was one of the banner years of the industry. In the face of curtailed operations on the part of some large consuming interests, the gain in soda ash distribution is explained by the fact that other industries increased their commitments. For instance, the chemical industry which, as a whole, was less active than in 1926, consumed a larger tonnage last year. In large part this was due to the larger outputs of caustic soda and silicate of soda. The soap trade, also, was a larger buyer of ash not only because of a small increase in soap manufacture but also because there was a trend toward the use of ash in place of caustic soda. In like manner, the pulp and paper trade, although producing less than in 1926, increased takings of soda ash. A small gain was reported in sales to petroleum refiners but there was no development in the possibility of utilizing ash in crude petroleum fields. Export trade remained relatively small with a small improvement over the preceding year. The status of export trade may be seen from the fact that it is only about one-third what it was in 1920.

In contrast to the export situation, demand for soda ash for domestic de-

livery has been steadily expanding. Census figures for 1923 and 1925 place total volume of sales at 1,258,780 tons and 1,368,660 tons respectively. Revised estimates show a distribution of 1,493,000 tons and for 1927 it is estimated that sales reached 1,528,000 tons, a gain of 35,000 tons for the year.

Larger production combined with improvements in plant operations have brought about lower price levels for soda ash in the last two years. In the

Chem. & Met.'s Annual Estimates of Soda Ash Sales

Industry	(Revised)	
	1926 Tons	1927 Tons
Glass works.....	665,000	640,000
Soap.....	200,000	225,000
Chemicals.....	200,000	220,000
Cleansing compounds and modified sodas.....	125,000	130,000
Pulp and paper.....	80,000	85,000
Water softening.....	72,000	70,000
Petroleum refining.....	25,000	27,000
Textiles.....	36,000	40,000
Exports.....	20,000	21,000
Miscellaneous.....	70,000	70,000
Total.....	1,493,000	1,528,000

latter part of 1926, contract prices for the ensuing year were reduced to \$1.17½ per 100 lb. in bulk and \$1.32½ per 100 lb. in bags, for light 58 per cent. In the last quarter of 1927, the announcement of contract prices for 1928 again carried a reduction, making quotations \$1.15 per 100 lb. in bulk and \$1.32 per 100 lb. in bags.

Larger Distribution of Caustic Potash

SOME of the consuming industries were reported to have been more active last year and a moderate gain is claimed in the volume of caustic potash which was taken from the market. Official figures for domestic caustic potash are not available but estimates place current yearly requirements at 8,500,000 lb. The larger part of supplies come from abroad and importation for the first eleven months of the year were 13,401,776 lb. valued at \$818,826 which represents an increase over the corresponding period of 1926 when arrivals from European markets amounted to 11,698,035 lb. valued at \$693,608. These figures illustrate the importance of the foreign-made product and point to the improbability of any expansion in domestic production unless there is a radical change in prevailing conditions.

Prices for caustic are featured by their steadiness with domestic material offered on a basis of producers works with freights working in favor of or against delivered prices in competition with imported caustic shipped from ports of entry. Liquid caustic potash is said to have gained in favor with shipments in tank cars reducing costs to consumers. Increased call for liquid caustic has favored the domestic material.

Caustic Soda Finds Larger Consuming Outlets

DESPITE reduced call from different consuming industries, further expansion was recorded in domestic caustic soda production and consumption during 1927. Export shipments were a little below the total reached in 1926 and reduced manufacturing operations cut down the amounts taken by various trades. Soap makers are tending toward a larger use of soda ash at the expense of caustic soda. Production

delivery throughout October but quiet trading prevailed in November followed by more active buying in December and the year closed with a large part of domestic production sold ahead.

Silicate of Soda Produced in Larger Volume

ACCORDING to census figures, domestic production of silicate of soda in 1925 was 394,824 tons, expressed in terms of the 40 deg. product. Definite figures are lacking for the output in 1927 but private estimates are that a material gain was recorded over the total for 1925. This is also indicated by sales to silicate companies of raw materials used in making silicate. The increase in use of paper cartons has widened the field for silicate in recent years and this outlet is still being extended. Soap makers also are classed as larger users of silicate and considerable quantities go to the ply-wood industry. Miscellaneous uses are numerous and while the individual trades are mostly small-lot buyers the aggregate from miscellaneous buyers adds appreciably to consuming totals. During the last year considerable progress is said to have been made in introducing silicate of soda as a road-binding material at the expense of chemicals which formerly monopolized that industry. This use of silicate also is reported to have found favor in European countries.

Apparently production of silicate of soda last year was in excess of consuming requirements as the market was unsettled and sellers were competing keenly. This competition in such a low-priced commodity placed emphasis on delivered costs and the question of freights has tended to localize the manufacturing industry. In fact there has been a trend toward breaking up production into small units located near consuming centers. There also has been a tendency to consolidate ownership of plants so as to reduce competition and possibly overhead. Rumors also have been current that control of silicate-producing plants was sought by manufacturing companies which had been finding unexpected competition from silicate of soda.

One of the encouraging features to trading in silicate of soda was the steadily increasing buying for export. Outward shipments of silicate for the eleven months ended November amounted to 50,887,070 lb. as compared with 44,850,145 lb. for the corresponding period of 1926. In fact exports in 1927 were the largest in the history of the trade. Imports of silicate are unimportant.

Prices for silicate of soda are usually given on a basis f.o.b. works but sales last year were largely a matter of private negotiation with sellers in many cases making efforts to equalize delivered costs to the consumer. Pressure also was noted in the market at times due to surplus offerings on the part of some producer-consumer.

Large Carryover of Arsenic and Arsenicals

UNDER the influence of enlarged boll weevil emergence much larger amounts of white arsenic went into calcium arsenate production last year than was the case in 1926. Sales of arsenate, however, did not come up to expectations and large stocks of arsenic, either as such or in the form of calcium arsenate were carried over into the new season and make it probable that there will be a falling off in arsenic consumption in the insecticide trade in the present year. Domestic production of arsenic in 1927 was about 10,300 tons and imports for the eleven months ended November were 24,088,745 lb. valued at \$864,216. This would give a total supply of about 23,000 tons. Of the imported material more than 9,000 tons came from Mexico, about 2,000 tons from Canada and the remainder from Japan and Europe. During the fiscal year ended August 31, 1927, the insecticide trade used 16,369 tons of arsenic. Of total consumption in 1927, 75 per cent went into insecticides, 15 per cent into glass, and 8 per cent into sodium arsenate and weed killers with miscellaneous lines accounting for the remaining 2 per cent.

Prices for arsenic were low during the last year but were more stable than was the case in 1926. A few odd lots were offered at times at special figures but in general the quotation was maintained at 3½c. per lb. for the first seven months after which a 4c. level was reached and maintained over the remainder of the year.

Prices for Chlorine Lower for 1928

UNCHANGED prices ruled throughout the year in the market for liquid chlorine and bleaching powder. The new contract prices for liquid chlorine, however, represented a decline of one-half cent per lb. The lower prices were said to have resulted from greater competition with a new producer in the field and also it was rumored that large consumers in the paper industry were planning to produce chlorine for their own consumption if they were not able to buy in the open market at prices lower than had been prevailing.

Producing of chlorine was reported by the Bureau of the Census at 166,325,643 lb. in 1925 and 125,361,020 lb. in 1923. Of this 104,960,186 lb. valued at \$4,236,307 and 76,118,240 lb. valued at \$2,778,088 were offered for sale. The figures for production do not include chlorine made and consumed in the paper and wood-pulp industry.

Export trade in bleaching powder was of a declining nature and totaled 15,935,679 lb. valued at \$293,663 in the first eleven months of 1927 in comparison with 19,717,582 lb. valued at \$363,145 in the first eleven months of 1926.

Chem. & Met.'s Annual Estimates of Caustic Soda Distribution

Industry	(Revised)	
	1926 Tons	1927 Tons
Soap.....	100,000	90,000
Chemicals.....	85,000	80,000
Petroleum refining.....	75,000	82,500
Rayon.....	60,000	65,000
Lye.....	40,000	35,000
Exports.....	52,000	48,000
Textiles.....	38,000	42,500
Rubber reclaiming.....	30,000	31,000
Vegetable oils.....	10,000	12,000
Pulp and paper.....	35,000	33,000
Storage battery.....	5,000	4,000
Miscellaneous.....	17,000	29,000
Total.....	547,000	552,000

of lye is gradually declining with a corresponding drop in demand for caustic soda. In the pulp field call for alkali was lessened somewhat but the falling off was not large because of the growing use of certain pulps in rayon manufacture. Rayon manufacture, itself, also offers an expanding outlet for the alkali and the same held true for oil refining. The export field is highly competitive but outward shipments still maintain a respectable tonnage. The following figures show export trade and domestic production for the years enumerated, production data for 1923 and 1925 being based on census returns and for the other years based on trade estimates:

PRODUCTION AND EXPORTS OF CAUSTIC SODA

	Production Ton	Exports Lb.
1921.....	238,591	101,021,827
1923.....	430,961	114,683,728
1924.....	408,000	92,115,631
1925.....	497,000	100,954,500
1926.....	547,000	103,294,775
1927*.....	552,000	88,792,420

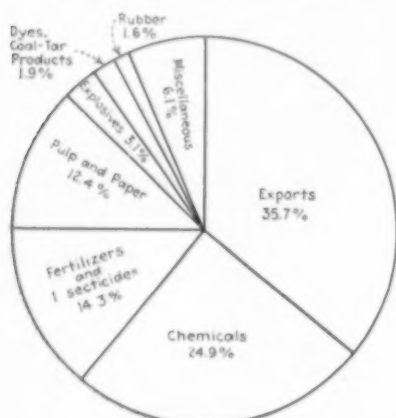
*11 months ended November.

The greater part of production comes from the lime-soda process with a little more than one-third of total output produced by the electrolytic process.

In the latter part of 1926 lower contract prices were named for soda ash for 1927 delivery and this had an unsettling effect on values for caustic and 1927 contracts for the latter were written at different price levels with large consumers finding no trouble in shading the open quotation of \$3 per 100 lb. for solid 76 per cent. Ash prices for 1928 delivery were again lowered late in the year and makers of caustic offered deliveries over the coming year at \$2.80 per 100 lb. which price also was subject to shading. A large tonnage of caustic was booked for future

Sulphur Distribution Aided By Export Orders

DOMESTIC manufacturers of sulphuric acid reduced their requirements for sulphur during the year and as some other industries which make use of sulphur as a raw material were not operating as actively as in 1926, total domestic of sulphur fell off from the total reported for 1926. Record shipments to foreign countries, however, made up for the decline in domes-



Sulphur Sales By Industries

tic trade and shipments from mines is estimated at approximately 2,100,000 tons as compared with 2,072,687 tons in 1926. Production for 1927 was about 2,000,000 tons so that stocks in sellers' possession at the end of the year were reduced to 2,150,000 tons.

In the following table will be found statistics representing domestic production and consumption of sulphur:

DOMESTIC PRODUCTION OF SULPHUR

	Production Tons	Domestic Consumption Tons
1917.....	1,134,412	968,615
1918.....	1,353,525	1,135,672
1919.....	1,190,575	453,622
1920.....	1,255,249	1,040,219
1921.....	1,679,130	668,675
1922.....	1,830,942	865,920
1923.....	2,036,097	1,146,780
1924.....	1,220,561	1,051,544
1925.....	1,409,240	1,228,469
1926.....	1,890,057	1,495,721
1927.....	2,000,000	1,350,000

Distribution of sulphur in domestic consuming industries in 1927 is estimated as follows:

DISTRIBUTION OF SULPHUR IN 1927

	Tons
Heavy chemicals.....	490,000
Fine chemicals.....	13,000
Electro-chemicals.....	20,000
Dyes and coal-tar products.....	40,000
Fertilizer and insecticides.....	300,000
Petroleum products.....	1,000
Pulp and paper.....	260,000
Rubber.....	35,000
Food products.....	3,000
Paint and varnish.....	5,000
Explosives.....	65,000
Miscellaneous.....	118,000
Total Domestic Consumption.....	1,232,000
Exports.....	750,000
Total Distribution.....	2,100,000

Prices for sulphur were on a steady basis throughout the year with \$18 per ton at mines as the general quotation

with open asking prices ranging up to \$19 per ton. Export shipments were generally quoted f.a.s. with the quotation representing the price at mine plus freight to shipping port.

Nitrate of Soda Improved Position During Year

WHILE synthetic nitrogen products continue to supply a large part of world consumption of nitrogen, the nitrate of soda industry recovered somewhat from the depression which had demoralized the industry. Exports from Chile in 1927 showed a material gain over those for 1926 and a fair volume of orders is held by producers for shipment over the remainder of the nitrate. Furthermore plans have been

STATISTICS ON NITRATE OF SODA

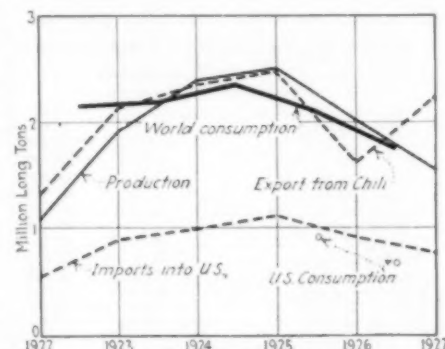
(Data for calendar years except consumption figures which are for fertilizer years ending June 30.)

Year	Production (Thousands of Metric Tons)	Exports from Chile (Thousands of Metric Tons)	Imports into United States (Thousands of Long Tons)	World Con- sumption (Thousands of Metric Tons)
1922	1,072	1,313	542	.....
1923	1,906	2,266	892	2,159
1924	2,403	2,363	986	2,192
1925	2,520	2,517	1,112	2,340
1926	2,016	1,614	914	2,092
1927	1,550	2,250	750	1,753

formulated for placing the industry on a more stable basis and it is possible that the export tax on shipments from Chile may be modified or removed before the coming of the new nitrate year. Prices for nitrate also were on a higher scale than in 1926.

World stocks of Chilean nitrate have

varied widely during recent years. At the end of 1926 the visible world stocks were estimated as 1,840,000 metric tons. Latest available estimates for the end of 1927 indicate visible world stocks of 1,410,000 metric tons. This is a reduction during the year of about 22 per cent. But the stock at the end of the year is substantially greater than at mid-year when a minimum visible world stock as low as 1,170,000 was reported. Apparently the anxiety of Chilean producers to take advantage of the slight apparent increases in consumption has



CHILEAN NITRATE IN RECENT YEARS
(Data from Dept. of Commerce)
Consumption estimates by Aikman, Ltd. London

occasioned again a production in excess of consumption, even considering seasonal factors. Reports late in December indicate, however, that there is expected to be a curtailment in the rate of production in January, partly explained by the annual stock-taking, but also in part due to a realization that recent increases in production were not altogether justified.

By-Products Obtained from Coke-Oven Operations in 1926

Product	Gal.	Production	Quantity	Sales	
				Total	Average
Tar.....	Gal.	529,486,374	277,248,522	\$14,103,760	\$0.051
Ammonia:					
Sulphate.....	Lb.	1,167,859,453	1,152,141,717	24,658,031	.021
Ammonia liquor (NH ₃ content).....	Lb.	53,523,229	53,448,034	3,470,172	.065
				28,128,203	
Sulphate equivalent of all forms.....	Lb.	1,381,952,369	1,365,933,751		
Gas:					
Used under boilers, etc.....	M. cu. ft.		25,953,876	1,438,699	.055
Used in steel or affiliated plants.....			249,840,649	27,955,574	.112
Distributed through city mains.....			89,565,953	29,978,997	.335
Sold for industrial use.....			32,553,610	5,313,530	.163
			397,914,088	64,686,800	.163
Light oil and derivatives:					
Crude light oil.....	Gal.	† 164,059,552	10,783,568	1,330,208	.123
Benzol, crude.....	Gal.	4,744,713	4,660,621	1,109,974	.238
refined.....	Gal.	17,713,904	17,327,169	3,957,719	.228
Motor benzol.....	Gal.	90,029,972	89,501,212	16,863,109	.188
Toluol, crude.....	Gal.	432,317	400,308	127,298	.318
refined.....	Gal.	8,359,135	8,250,297	2,787,454	.338
Solvent naphtha.....	Gal.	4,704,555	3,546,117	1,035,870	.292
Other light oil products.....	Gal.	4,127,710	1,324,303	93,344	.070
		† 130,112,306	135,793,595	27,304,976	.201
Naphthalene:					
Crude.....	Lb.	7,746,821	7,556,372	96,210	.013
Refined.....	Lb.	139,701	166,851	1,100	.007
		7,886,522	7,723,223	97,310	.013
Other products.....				148,720	
Value of all by-products sold.....				\$ 134,469,769	

* Includes gas wasted and gas used for heating retorts.

† Refined on the premises to make the derived products shown, 159,589,756 gallons.

‡ Total gallons of derived products.

§ Exclusive of the value of breeze production.

Imported Tartaric Acid in Larger Supply

COMPETITION between foreign and domestic makers has been a feature of the market for tartaric acid since the close of the war. That sales of the imported product gained ground during the year is attested by import statistics for the first eleven months of the year which place arrivals at domestic ports at 2,587,139 lb. valued at \$579,370 as compared with 1,486,292 lb. valued at \$313,096 for the corresponding period of 1926. According to census figures production of tartaric acid in 1925 was 5,498,920 lb. Imports in that year amounted to 3,580,253 lb. This would give a total supply of 9,079,173 lb. and would indicate that domestic consumption was somewhat less than that total as stocks were reported to be large. Imports of argols, cream of tartar, and wine lees for the first eleven months of 1927 were 23,455,428 lb. compared with 24,149,726 lb. in the corresponding period of 1926. These totals point to a small falling off in the domestic output of tartaric acid last year and the increase in importations leads to the same conclusion.

A petition for an increase in import duty on tartaric acid and cream of tartar has been before the Tariff Commission for more than a year. The present duty on tartaric acid is 6c. per lb. and on cream of tartar 5c. per lb. The petitions have been considered together and the investigation into producing costs has been completed but public hearings have not yet been scheduled. As France enters into the cream of tartar situation, the matter was held up while tariff questions between this country and France were started recently. It has been suggested that tartaric acid be

Domestic Production and Sale of Ammonia Products

(Quantities in Net Tons of Nitrogen Contained)		
Production:		
	1926	1927
At coke works.....	138,000	136,000
At gas works.....	5,200	5,600
From the air.....	12,800	18,200
Bone distillation, etc.....	200	200
Imports*		
Ammonium sulphate.....	1,900	3,800
Ammonium sulphate-nitrate.....		9,400
Total available.....	158,100	173,200
Disposition:		
In mixed fertilizers.....	55,000	55,000
Sulphate and other compounds used as fertilizer.....	2,200	2,500
Anhydrous ammonia, used mainly as refrigerant.....	15,000	16,500
Aqua ammonia.....	25,000	24,000
In ammonia explosives.....	8,200	8,200
In ammonium salts, miscellaneous chemicals.....	5,300	5,500
Industrial uses—rayon, soda ash, etc.....	7,000	7,000
Ammonia oxidation.....	1,200	2,500
Exported as sulphate of ammonia.....	38,800	31,300
Increase in stocks and unaccounted for.....	400	20,700
Total disposition.....	158,100	173,200
* Does not include chemicals imported and used as such.		

taken up separately so as to expedite a decision. The future market for tartaric acid will depend largely on the action taken on the duty.

Domestic production of cream of tartar in 1925 was 7,072,651 lb. and imports that year were 315,652 lb. The combined total is fairly representative of domestic consumption.

New Standard for Rosin

On December 31, a new standard for extra red grade of rosin was established by the Secretary of Agriculture. The new standard is designated as FF.

Ammonia Improved Position Last Year

THE unsettled position which characterized the market for aqua and anhydrous ammonia as soon as synthetic products made their appearance was bettered materially by developments of last year. The number of producers of synthetic ammonia was reduced to five by the end of the year and total output also was reduced. Improvements in operating methods were reported and with smaller supplies coming on the market sales prices were strengthened and higher contract prices went into effect for deliveries over 1928. The general situation likewise was aided by a falling off in production of byproduct ammonia. Trading in ammonia is largely on a basis of long-term contracts and producers were carrying numerous contract orders at the close of the year which insured a good distribution in the present year.

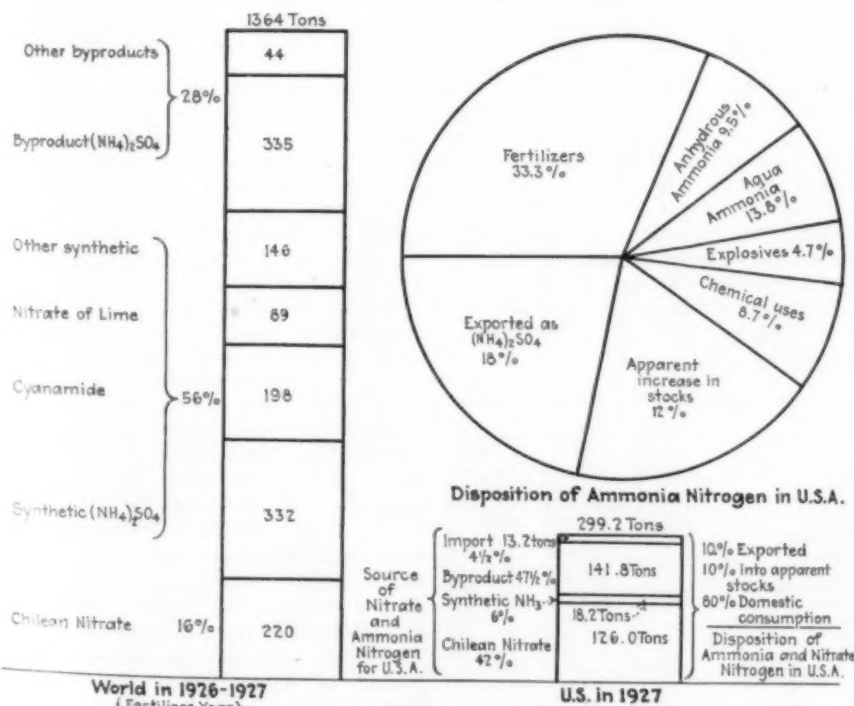
Census figures place production of anhydrous ammonia at 31,724,858 lb. and 23,529,382 lb. in 1925 and 1923 respectively. The output of aqua ammonia in the same years was 102,488,362 lb. and 67,425,904 lb. of which 66,227,965 lb. and 38,694,140 lb. was offered for sale.

Acetate of Lime Improved Its Position

WOOD distillation chemicals which suffered a setback with the appearance on the market of synthetic methanol and with reports that synthetic acetic acid would soon follow, scored a partial recovery last year in the case of production and sales of acetate of lime according to the latest available figures. Data covering the year through November show a gain in production, in shipments, and also a slight drop in stocks. The increase in apparent consumption must be accounted for in domestic circles as export trade fell off during the year, the total for the first eleven months being 9,555,619 lb. as compared with 17,914,211 lb. in the corresponding period of 1926. Prices for acetate of lime were barely steady at times but the open quotation was maintained at unchanged levels throughout the period. Reports from Canada show a situation similar to that reported in this country as both production and shipments gained in volume during the year.

PRODUCTION AND SHIPMENTS OF ACETATE OF LIME

	1926	Production	Shipments
November	14,100,075	15,509,609	
Total (11 mos.)..	143,608,972	141,952,018	
1927			
January	14,180,664	10,067,060	
February	12,667,411	10,183,748	
March	14,223,334	14,001,601	
April	13,138,663	13,559,589	
May	12,552,019	11,971,888	
June	12,070,249	14,195,951	
July	11,744,922	12,194,890	
August	13,324,634	14,516,485	
September	12,957,833	13,297,537	
October	13,911,770	16,959,493	
November	13,518,867	13,610,790	
Total (11 mos.)..	144,290,366	143,539,037	



Keen Competition in Market for Sal Ammoniac

THE most striking development in the market for sal ammoniac last year, was found in the competitive selling which arose between domestic and foreign producers. Increased use of sal ammoniac in the battery trade gave an impetus in 1926 both to domestic production and to imports. With sales assuming larger yearly proportions and surplus ammonia existing in this country, the number of domestic producers of sal ammoniac increased and only declining market values kept still more companies from entering the production field. The competition between home producers and importers continued into 1927 and as the year progressed it became more prominent through the medium of further price reductions. In the latter part of the year open market quotations for both the white and gray selections were the lowest in the history of the trade. Attempts of domestic producers to curtail sales of imported material met with little success as official returns give importations for the first eleven months of 1927 as amounting to 13,519,178 lb. valued at \$483,968 as compared with arrivals of 13,290,605 lb. valued at \$523,314 in the corresponding period of 1926.

Lower Average Prices for Linseed Oil

MARKET values for flaxseed and linseed oil are largely independent of local conditions and are governed by the position of the world's markets. The seed supply for the world in 1927, based on carryover and new production was reported at 16.7 per cent above the corresponding supply for 1926. While flaxseed is grown in many places, the four principal sources are the United States, Canada, Argentina, and India. To these Russia might be added but the greater part of Russian seed is consumed at home. India sends its production to the United Kingdom and the United States is interested principally in Canada and the Argentine. Production of seed in the latter countries is shown in the following table:

FLAXSEED PRODUCTION IN 1927		
	Area Acres	Yield Bu.
United States.....	2,907,000	26,583,000
Canada.....	476,000	4,735,000
Argentina.....	7,055,000	85,030,000

Because it is the largest producer of seed, the Argentine has the greatest effect on the markets of the world. The present crop in that country is estimated at 85,030,000 bu. which would give an exportable surplus of about 78,000,000 bu. This is a record production and is of bearish significance on future values for seed and oil. Imports of flaxseed for the first eleven months of 1927 were 20,792,008 bu. of which 18,396,243 bu. came from the Argentine. For the corresponding period of 1926, imports amounted to 21,360,203 bu. of

which 18,412,530 bu. came from the Argentine.

Domestic production of linseed amounted to 720,109,940 lb. and 763,822,379 lb. in 1926 and 1925, respectively. In the first nine months of 1927, production was officially reported at 538,668,395 lb. As the last quarter of the year generally finds heavy production of oil, it is estimated that total production for the year will surpass that for 1926 and approximate that for 1925.

Both production and consumption of linseed oil have been stimulated by the relatively low prices which prevailed over the greater part of last year and large contract placements are held by crushers, calling for 1928 delivery.

Cottonseed Oil Stocks Create Record

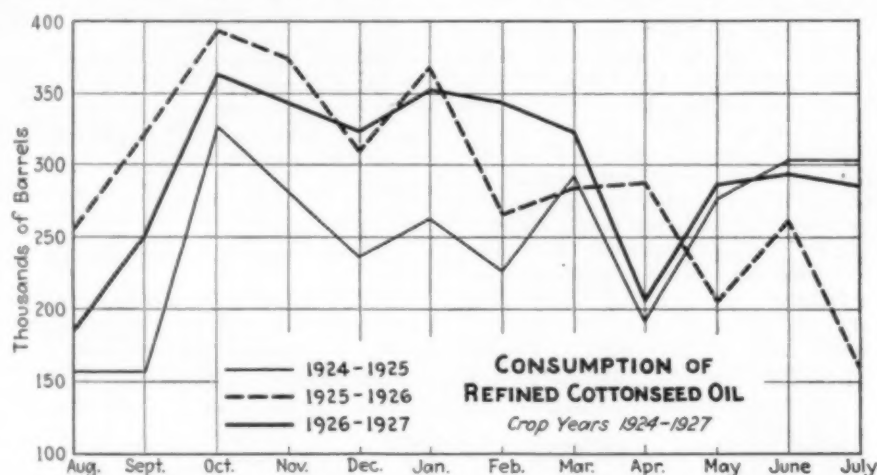
CARRYOVER stocks of cottonseed oil at the beginning of the oil year, August 1, 1927, were the largest on record and in terms of refined oil were equivalent to approximately 1,000,000 bbl. The 1927 crop of seed fell off in

four-month period August to November, inclusive, totaled only 1,240,000 bbl. as compared with 1,345,000 bbl. in the corresponding period of the preceding year.

Undoubtedly the market for the remainder of crop year will be influenced largely by the volume of sales but in view of increased sales of fertilizer this season and the probability of diminished boll weevil emergence next Spring because of the cold weather which has been experienced in cotton-producing states, buyers of oil will not anticipate wants to any extent until an approximate idea may be gained regarding the next cotton crop and its supply of cottonseed.

Sharp Price Fluctuations for Wood Oil

TRADING in China wood oil during last year was characterized by the wide ranges in prices quoted at different times. While progress has been made in developing a domestic supply of wood oil, the country still is dependent on China. Conditions in primary markets



quantity materially from that for the preceding season and under the influence of large consuming demand the markets recovered from the low levels reached in the latter part of 1926 but the visible supply at all times was large enough to hold prices on a relatively low basis and must be regarded as the most important factor in the year's market. Consumption of cottonseed oil for the last two crop years compares as follows:

	REFINED COTTON OIL CONSUMPTION	
	1926-27 Bbl.	1925-26 Bbl.
August	185,000	254,000
September	251,000	321,000
October	363,000	395,000
November	343,000	375,000
December	325,000	309,000
January	352,000	369,000
February	346,000	266,000
March	322,000	282,000
April	206,000	288,000
May	287,000	206,000
June	295,000	261,000
July	287,000	158,000
	3,572,000	3,484,000

Consumption of oil in the 1927-28 crop year started off heavily but for the

therefore are paramount as price factors and internal difficulties in China served at times to cut off the movement of oil from interior points and as stocks at Hankow and other terminals were not large, there were delays in making shipments and the uncertainty about future supplies had a decidedly strengthening effect on prices as may be noted by reference to shipment quotations which ranged from 10½c. per lb. to 29c. per lb. with a corresponding effect on spot values in domestic markets. Toward the close of the year, the market was again moving upward with advices from China stating that there were practically no stocks at terminals with river deliveries irregular with the river very low.

The supply of China wood oil, however, was larger in 1927 than in 1926 as the official returns place imports for the eleven months ended November, at 86,708,371 lb. as compared with 75,430,785 lb. in the corresponding period of 1926. Total exports from Hankow in December amounted to 7,281,890 lb. of which 5,173,245 lb. was destined for the United States.

Exports of Chemical and Allied Products

		12 Months Ended December				11 Months Ended November	
		1925		1926		1927	
		Quantity	Value	Quantity	Value	Quantity	Value
Animal oils							
Oleo oil	Lb.	91,971,845	\$11,814,197	96,901,849	\$11,784,959	74,348,420	\$8,876,649
Neatfoot oil	Lb.	1,431,399	253,117	1,083,333	197,813	1,341,801	208,064
Other animal oils	Lb.	2,146,601	281,146	660,388	79,775	923,608	99,149
Fish oils	Lb.	614,274	115,078	808,827	118,986	653,163	74,654
Oleo stock	Lb.	12,187,126	1,527,944	12,158,913	1,413,913	11,600,093	1,326,766
Tallow	Lb.	17,514,444	1,624,093	10,628,324	958,151	6,095,235	515,608
Lard	Lb.	688,828,950	118,089,981	698,970,920	108,600,027	618,447,537	83,532,453
Lard compounds	Lb.	14,090,716	2,041,215	10,580,822	1,484,843	8,481,055	1,015,477
Stearin and fatty acids							
Oleo and lard stearin	Lb.	7,394,780	960,742	7,317,648	874,171	5,306,468	560,835
Grease stearin	Lb.	2,629,160	295,543	2,428,643	269,522	3,477,162	330,679
Oleic acid or red oil	Lb.	490,773	51,471	852,411	85,717	1,991,858	174,210
Stearic acid	Lb.	1,931,374	282,761	1,011,540	139,054	2,149,636	245,267
Oleomargarine	Lb.	774,489	134,133	1,577,530	217,629	743,138	119,971
Other animal greases, oils, fats	Lb.	81,264,163	9,393,772	72,639,779	6,939,651	75,437,588	6,669,969
Glue, animal origin	Lb.	2,545,783	384,540	2,463,005	381,210	2,196,734	358,171
Wax manufactures	Lb.	1,292,157	288,165	2,914,017	482,794	1,688,358	362,267
Oil cake and meal							
Cottonseed cake	Lb.	561,446,037	11,571,397	541,231,467	8,854,479	562,247,021	10,232,775
Lined cake	Lb.	638,532,208	14,238,001	577,236,317	12,109,257	596,635,284	12,385,992
Other oil cake	Lb.	17,697,659	272,904	14,747,949	218,394	22,669,992	340,256
Cottonseed meal	Lb.	237,522,841	4,938,391	300,886,896	4,951,181	232,197,266	3,958,439
Lined meal	Lb.	12,159,124	283,779	13,490,402	285,103	12,662,624	261,311
Other oil meal	Lb.	20,398,324	361,330	2,165,343	39,169	2,435,709	40,739
Oil seeds	Lb.	3,685,747	278,664	2,452,145	167,949	1,470,274	92,180
Vegetable oils, expressed and fats							
Lined oil	Lb.	2,487,134	355,480	2,567,013	250,772	2,388,391	287,363
Soya bean oil	Lb.	519,668	43,579	1,567,058	190,576	4,783,584	536,990
Coconut oil	Lb.	17,901,213	1,763,741	15,952,287	1,545,490	18,434,974	1,609,310
Cottonseed oil, crude	Lb.	33,553,552	3,035,930	27,356,852	2,486,102	43,759,073	3,517,630
Cottonseed oil, refined	Lb.	28,861,920	3,480,970	13,543,666	1,603,549	15,919,684	1,675,338
Corn oil	Lb.	3,847,330	517,919	1,324,114	190,454	264,019	30,565
Vegetable soap stock	Lb.	7,750,925	498,882	12,398,646	681,440	9,964,028	527,055
Other vegetable oils and fats	Lb.	8,536,683	941,468	7,815,677	1,066,558	7,132,859	1,066,972
Naval stores							
Rosin	Bbl.	1,172,335	18,888,525	1,094,323	24,633,310	1,229,896	21,059,113
Spirits of turpentine	Gal.	11,557,221	11,346,464	11,586,590	10,636,166	14,463,086	8,794,294
Wood turpentine	Gal.	585,605	439,275	685,193	530,303	620,318	366,436
Tar and pitch, wood	Bbl.	25,044	202,490	24,468	219,644	26,138	235,893
Other gums and resins	Lb.	2,807,124	933,438	3,095,008	845,237	3,366,131	1,025,855
Dye extracts							
Logwood extract	Lb.	2,225,358	251,640	1,862,306	204,137	2,398,381	221,948
Other dye extracts	Lb.	1,396,167	150,993	666,490	138,370	951,285	88,523
Dyeing and tanning							
Materials, crude	Ton	8,011	141,477	1,341	60,231	1,464	78,499
Tanning extracts							
Chestnut	Lb.	7,286,552	216,644	6,176,455	174,590	5,477,325	166,837
Other tanning extracts	Lb.	21,515,249	1,178,447	24,847,387	1,261,570	26,956,758	1,416,538
Starch							
Cornstarch	Lb.	222,267,247	7,977,655	203,789,194	6,240,751	213,511,271	6,588,986
Other	Lb.	10,482,103	378,550	21,551,038	622,517	9,060,764	313,604
Mineral oils							
Petroleum, crude	Bbl.	13,125,150	24,274,965	15,406,045	28,495,773	14,126,098	22,987,691
Petroleum, refined	Bbl.	93,937,925	422,894,326	108,423,242	497,482,192	107,050,129	399,908,206
Mineral spirits	Gal.	1,055,453	309,046	1,762,852	395,578	2,465,295	506,615
Gas and fuel oil	Gal.	32,508,547	49,040,024	34,516,390	45,354,108	39,615,943	46,147,779
Paraffin wax							
Unrefined	Lb.	72,289,357	3,863,776	70,948,114	3,657,561	63,135,878	3,262,512
Refined	Lb.	261,890,054	14,761,098	264,613,173	15,275,765	244,038,204	14,059,452
Petroleum asphalt	Ton	79,477	1,762,048	130,883	3,183,746	318,907	7,711,424
Lime	Bbl.	147,995	218,696	129,607	191,905	145,805	196,025
Sulphur	Ton	629,401	11,000,235	576,966	10,918,394	735,795	15,072,424
Salt	Lb.	310,158,759	1,219,935	317,815,256	1,277,764	288,515,422	1,247,909
Plate and window glass							
Window glass	Box	25,131	143,313	30,976	184,206	20,492	113,000
Plate, unslivered	Sq. Ft.	1,578,657	407,440	855,157	243,371	982,443	307,378
Other	Lb.	2,447,333	272,891	3,026,006	271,941	3,819,027	396,485
Chemical glassware	Lb.	226,798	176,790	226,683	205,854	196,546	177,431
Ferro-alloying ores and metals							
Ferromanganese and spiegeleisen	Ton	5,496	160,568	693	44,111	1,566	58,176
Ferrotungsten, etc.	Lb.	13,238	143,987	29,380	155,653	19,575	151,818
Other	Lb.	3,877,802	362,826	6,031,800	618,439	7,037,088	793,946
Printers ink	Lb.	11,304,849	1,330,329	10,894,990	1,439,292	9,546,388	1,163,434
Paste and mucilage	Lb.	3,500,503	399,373	3,335,093	373,319	3,029,180	294,819
Candles	Lb.	1,383,936	251,618	1,253,256	254,596	1,046,557	238,396
Rubber and manufactures							
Magnesia and manufactures	Lb.	5,264,203	316,978	6,579,221	59,205,260	5,211,197	63,199,794
Chemicals and related products							
Coal-tar products							
Crudes							
Benzol	Lb.	58,800,162	1,748,034	143,527,826	5,513,173	210,353,593	6,105,340
Crude tar and pitch	Bbl.	108,795	326,925	108,937	430,349	13,674,200	3,059,085
Other crudes	Lb.	20,498,923	640,597	25,368,381	663,351	2,191,350	417,979
Intermediates	Lb.	2,531,198	471,144	1,749,834	339,579	2,191,350	340,956
Finished products							
Coal-tar colors, dyes, etc.	Lb.	25,799,889	6,694,300	25,811,941	5,950,159	24,544,218	5,066,799
Medicinals	Lb.	728,000	447,143	733,408	386,537	625,786	303,978
Other	Lb.	3,417,128	432,699	1,746,261	357,037	3,847,350	536,539
Medicinal and pharmaceutical preparations							
Quinine sulphate and other cinchona salts	Os.	688,024	237,331	289,627	144,175	215,237	97,359
Antitoxins, sera, and vaccines	Lb.		1,248,874		1,439,228		1,584,930
Medicated plasters	Lb.	499,746	644,567	445,367	584,611	295,732	395,379
Other			17,636,761		17,508,765		16,196,547
Crude drugs, dyeing and tanning materials							
Drugs, herbs, leaves, roots	Lb.	138,131	1,668,221	180,262	2,640,488	155,492	2,297,476
Ginseng	Lb.	5,742,695	1,292,892	4,922,013	937,156	4,599,407	957,175
Essential oils							
Peppermint	Lb.	68,038	775,703	67,809	570,742	188,457	270,575
Other	Lb.	1,320,877	897,593	3,066,699	1,124,729	3,288,445	1,178,341

Exports of Chemicals and Allied Products—Continued

		12 Months Ended December				11 Months Ended November	
		1925		1926		1927	
		Quantity	Value	Quantity	Value	Quantity	Value
Acids and anhydrides							
Sulphuric.....	Lb.	7,537,134	\$151,819	9,224,406	\$174,423	6,971,412	\$152,134
All other.....	Lb.	15,607,892	829,265	16,382,042	830,488	12,134,058	699,292
Alcohols							
Methanol, pure and denaturing.....	Gal.	408,185	321,308	417,265	311,508	271,903	235,524
Other alcohol.....	pf. Gal.	454,018	387,432	425,483	235,147	416,522	429,432
Ammonia and ammonium compounds.....	Lb.	4,521,008	870,987	4,877,661	675,251	4,009,346	502,757
Aluminum sulphate.....	Lb.	41,512,316	505,537	60,005,389	888,816	38,759,255	451,736
Baking powder.....	Lb.	4,026,317	1,533,222	4,500,523	1,634,452	4,371,926	1,576,344
Calcium compounds							
Acetate of lime.....	Lb.	22,038,213	684,577	18,588,831	626,446	9,555,619	349,741
Calcium carbide.....	Lb.	4,854,637	208,354	4,533,725	184,094	4,665,400	187,183
Bleaching powder.....	Lb.	27,389,007	472,497	20,858,158	387,972	15,935,679	293,663
Copper sulphate.....	Lb.	6,139,344	287,870	4,798,620	231,175	5,301,320	275,790
Dextrine or British gum.....	Lb.	22,678,346	1,030,859	22,363,444	906,419	22,949,555	934,197
Formaldehyde.....	Lb.	2,799,116	291,156	2,386,536	225,923	1,861,353	176,990
Glycerin.....	Lb.	1,367,191	282,078	767,698	192,220	485,032	106,773
Petroleum jelly.....	Lb.	6,482,077	1,074,973	5,094,703	898,576	4,894,215	789,490
Disinfectants, insecticides, fungicides and similar preparations and materials.....	Lb.			13,189,815	2,721,990	20,362,010	4,469,763
Potassium compounds.....	Lb.	4,310,188	398,740	3,356,364	319,201	2,578,728	414,356
Sodas and sodium compounds							
Bichromate and chromate.....	Lb.	7,299,336	444,630	8,526,936	531,129	7,902,670	501,030
Cyanide.....	Lb.	1,591,633	273,937	1,883,353	305,398	1,064,390	172,913
Borax.....	Lb.	33,888,235	1,528,035	28,610,037	1,256,798	66,805,686	2,182,583
Soda Ash.....	Lb.	32,380,108	775,478	39,533,152	936,451	38,166,365	910,786
Silicate.....	Lb.	40,517,037	353,944	48,344,537	396,496	58,887,070	401,279
Salt soda.....	Lb.	13,391,541	195,329	12,652,716	159,810	11,916,846	152,756
Caustic.....	Lb.	100,954,500	2,995,724	103,294,775	3,111,510	88,792,420	2,642,913
Bicarbonate.....	Lb.	17,297,561	350,585	19,338,710	372,700	16,958,810	312,838
Other sodium compounds.....	Lb.	108,025,316	1,435,094	83,853,730	1,356,695	71,582,064	1,457,388
Washing powder and fluid.....	Lb.	4,515,511	273,624	4,935,243	263,499	4,979,411	280,225
Other chemicals, medicinal and pharmaceutical.....	Lb.	82,388,420	9,073,752	95,218,345	9,379,430	9,457,456	9,457,456
Pigments, paints and varnishes.....			18,510,021		18,886,627		19,024,459
Mineral earth pigments, ochre, umber, sienna, metallic, whiting, etc.....	Lb.	31,264,521	902,833	31,955,495	1,006,377	34,841,570	1,035,802
Chemical pigments							
Zinc oxide.....	Lb.	21,710,048	1,503,561	29,322,592	1,917,420	26,907,082	1,692,654
Lithopone.....	Lb.	2,573,354	132,771	3,881,329	200,412	3,905,911	206,495
Carbon black.....	Lb.	3,805,340	249,613	1,528,677	241,551	2,722,179	173,707
Red lead.....	Lb.	43,182,635	3,556,769	39,210,389	3,621,907	48,811,346	4,126,381
White lead.....	Lb.	1,604,497	183,591	1,550,364	175,273	2,728,190	256,823
Other chemical pigments.....	Lb.	13,663,309	1,293,168	12,478,333	1,119,350	10,427,441	821,848
Paints, stains and enamels							
Enamel paints.....	Lb.	6,525,922	760,106	5,575,711	707,241	3,617,003	472,503
Other ready-mixed paints.....	Gal.		882,451		433,074		434,290
Other paints.....	Lb.	2,236,847	4,657,782	2,207,834	4,590,011	2,405,719	4,888,365
Varnishes							
Oil varnishes.....	Gal.	11,437,948	2,363,353	9,972,821	2,119,903	8,992,110	1,814,648
Other varnishes.....	Gal.	712,003	1,279,373	631,499	1,127,543	451,418	808,442
Fertilizers and fertilizer materials.....	Ton	394,637	745,650	476,445	912,185	742,013	1,620,250
Sulphate of ammonia.....	Ton	1,142,354	17,298,529	1,095,852	19,672,313	1,192,524	16,500,981
Other nitrogenous materials.....	Ton	123,141	6,748,728	174,084	9,456,154	132,034	6,516,739
Phosphate materials							
Phosphate rock—							
High-grade hard rock.....	Ton	6,802	367,435	9,639	566,306	8,630	469,820
Land pebble.....	Ton	158,985	2,283,076	103,572	1,195,729	127,174	878,883
Superphosphates (acid phosphate).....	Ton	697,891	3,287,370	634,362	3,155,732	734,796	3,586,988
Prepared fertilizer mixtures.....	Ton	65,779	988,914	64,362	932,794	100,563	1,468,796
Other fertilizers.....	Ton	29,923	1,530,354	27,050	1,025,245	14,150	594,102
Explosives							
Smokeless powder.....	Lb.	46,509	1,985,335	71,554	3,251,740	75,177	2,985,653
Other gunpowder.....	Lb.	1,128,176	621,067	614,277	453,163	186,588	123,242
Blasting powder.....	Lb.	445,911	146,637	671,675	163,434	449,354	165,019
Dynamite.....	Lb.	2,669,757	194,141	1,693,912	126,447	2,676,343	205,295
Other explosives.....	Lb.	16,986,044	2,444,362	16,221,096	2,330,533	10,563,129	1,569,440
Soap							
Toilet or fancy.....	Lb.	6,760,789	2,805,404	8,974,695	3,037,775	7,669,765	2,595,531
Laundry.....	Lb.	55,806,410	4,008,884	60,757,985	4,119,707	51,984,946	3,587,858
Other soap.....	Lb.	13,098,254	1,221,535	13,625,126	1,244,530	12,176,686	1,098,356
Perfumery and toilet waters.....	Lb.		450,740		391,428		339,092
Talcum and other toilet powders.....	Lb.	3,468,579	1,882,196	3,289,392	1,726,933	2,976,959	1,489,331
Creams, rouges, and other cosmetics.....	Lb.	2,535,379	1,331,409	2,921,443	1,624,452	2,723,670	1,561,916
Dentifrices.....	Lb.	3,405,724	3,211,272	491,034	359,301	585,513	332,674
Other toilet preparations.....	Lb.	1,744,711	1,207,637	1,759,521	1,280,910	1,925,736	1,444,134
Pyroxylin products, known as celluloid, pyralin, viscoloid, fiberloid, etc.....							
In blocks, sheets, or rods.....	Lb.	2,464,222	2,087,277	2,345,264	1,733,438		
Manufacturers of.....	Lb.	1,939,568	1,923,902	2,198,412	2,084,557		
Blackings and polishes							
Shoe polishes.....	Lb.	5,257,091	1,303,315	3,392,523	995,916	3,197,821	917,323
Other blackings and polishes.....	Lb.	5,674,185	865,698	5,786,172	968,321	5,307,504	920,353
Clays							
Fire clay.....	Ton	39,319	350,571	42,622	348,302	39,785	354,442
Other clays.....	Ton	34,827	530,965	37,640	644,416	42,114	654,138
Graphite and manufacturers.....	Lb.	4,270,394	479,603	4,283,538	512,319	3,373,227	402,297
Asbestos							
Unmanufactured.....	Ton	990	70,846	986	85,922	223	26,741
Paper, millboard and roloboard.....	Lb.	2,159,826	119,311	1,791,519	153,046	1,432,181	107,005
Pipe covering and cement.....	Lb.	4,553,452	280,082	4,265,600	257,128	4,234,161	238,627
Textiles, yarn and packing.....	Lb.	1,369,738	803,037	1,449,852	813,993	1,307,513	716,650
Other manufactures of asbestos, except roofing.....	Lb.	2,178,744	342,151	2,804,499	337,062	2,283,117	295,058
Carbons and electrodes							
Electrodes for electrical furnaces.....	Lb.	12,203,217	1,213,754	13,711,415	1,640,837	12,027,927	1,614,227
Other carbon products.....	Lb.	26,222,523	2,000,580	30,309,712	1,354,657	32,415,630	1,242,897
Chalk, manufactures of.....	Lb.	1,626,815	236,356	1,663,139	223,822	1,568,029	199,849
Gypsum or plaster, crude, ground, calcined, and manufactures of.....	Lb.	33,595,982	498,616	39,220,233	576,585	34,614,153	441,765
Fire clay bricks.....	M	22,938	643,729	25,639	708,278	26,828	825,053
Other refractory bricks.....	M	14,088	1,315,124	1,378,577	1,378,577	12,676	1,219,654
Refractory shapes.....	Lb.	26,517,893	679,399	27,703,451	698,531	37,749,735	729,174
Crucibles.....	No.	408,249	91,699	618,735	149,456	531,417	101,271
Nickel, monel metal and alloys.....	Lb.	2,569,185	834,529	1,598,538	428,820	1,926,690	549,999
Bauxite.....	Ton	78,633	4,134,455	87,770	4,741,260	111,055	7,106,854
Asphalt and bitumen, natural							
Unmanufactured.....	Ton	29,317	825,654	34,123	905,743	34,082	990,736
Manufactures, except roofing.....	Lb.	92,648,140	1,605,641	52,175,475	977,399	57,352,017	1,211,841

Imports of Chemical and Allied Products

		12 Months Ended December				11 Months Ended November	
		1925		1926		1927	
		Quantity	Value	Quantity	Value	Quantity	Value
Albumen, egg.....	Lb.	8,517,265	\$3,880,839	7,110,216	\$2,960,663	5,108,291	\$1,945,971
Animal and fish oils, fats and greases							
Whale oil.....	Gal.	7,399,372	4,328,414	8,457,870	4,225,455	5,276,270	2,630,808
Cod and cod-liver oil.....	Gal.	2,975,557	1,920,069	4,347,024	2,866,811	4,082,255	3,002,677
Other fish oils.....	Gal.	825,995	335,489	2,202,504	858,216	4,600,615	1,545,743
Wool grease.....	Lb.	10,068,425	350,110	11,843,543	471,503	10,450,039	405,023
Grease and oils, n.e.s.....	Lb.		202,185		564,666		344,155
Gelatin, edible.....	Lb.	3,119,709	637,391	2,420,857	494,568	2,464,526	481,729
Other.....	Lb.	1,675,431	1,001,459	2,087,735	1,195,581	1,951,128	1,109,479
Glue and glue size.....	Lb.	5,241,354	474,975	6,597,360	525,356	8,346,292	664,972
Casein.....	Lb.	18,803,816	1,573,335	26,281,126	2,851,537	23,250,693	2,985,483
Beeswax and other animal wax.....	Lb.	3,556,794	1,170,454	4,622,448	1,604,234	4,836,807	1,563,074
Oil cake and meal							
Bean.....	Lb.	27,801,936	535,800	42,869,167	885,013	45,570,436	859,741
Coconut.....	Lb.	30,371,260	463,807	38,374,901	445,423	34,218,261	410,618
All other.....	Lb.	30,362,210	580,075	39,310,859	794,087	85,230,959	1,457,856
Vegetable tallow.....	Lb.	6,423,896	505,497	3,778,830	312,222	5,226,749	360,350
Vegetable wax.....	Lb.	6,507,161	1,309,571	8,234,153	2,249,548	9,629,885	2,470,136
Varnish, gums and resins							
Damar.....	Lb.	12,697,218	1,568,894	15,155,967	2,279,580	14,645,228	2,039,835
Kauri.....	Lb.	4,634,495	813,234	5,455,974	951,982	3,677,817	541,047
Shellac.....	Lb.	19,912,799	10,164,050	31,295,602	10,515,096	23,552,994	9,711,278
All other.....	Lb.	37,037,081	5,856,599	51,343,933	6,562,559	45,773,042	6,627,258
Tar, pitch, and turpentine.....	Lb.		277,032		516,687		325,576
Gum, Arabic.....	Lb.	7,256,155	782,882	10,267,775	1,001,810	7,592,018	649,202
Tragacanth.....	Lb.	966,498	427,885	1,414,735	739,899	1,300,189	683,898
Gambier.....	Lb.	3,881,192	536,305	4,016,353	366,312	3,456,097	247,507
All other.....	Lb.	17,230,075	1,437,834	20,688,240	1,614,534	13,754,794	1,337,475
Oil seeds							
Cotton seed.....	Lb.	63,831,982	804,668	58,950,854	759,624	10,931,503	165,144
Castor beans.....	Lb.	107,231,669	4,840,512	10,908,439	3,385,101	98,866,788	3,514,388
Copra.....	Lb.	364,075,612	18,081,056	457,598,620	23,513,066	391,829,642	17,986,626
Flaxseed.....	Bu.	16,509,686	39,682,722	22,549,982	41,383,275	20,792,008	36,315,370
Poppy seed.....	Lb.	3,534,761	350,779	5,160,537	535,428	5,126,574	497,902
Perilla and sesame.....	Lb.			2,883,399	155,895	2,917,564	155,019
Other oil seeds.....	Lb.	20,016,223	965,369	17,980,006	772,259	14,635,442	603,913
Vegetable oils and fats							
China wood oil.....	Gal.	101,553,519	11,385,848	83,003,774	9,090,390	86,708,371	11,421,546
Coconut oil, free.....	Lb.	232,498,697	19,649,542	245,129,333	22,087,870	264,030,366	20,629,586
Cocoa butter.....	Lb.	63,831	18,027	85,933	2,307	187,367	57,878
Olive oil, edible.....	Lb.	90,426,346	15,656,307	78,505,939	13,901,274	71,948,566	16,884,045
inedible.....	Gal.	10,884,398	1,233,956	9,925,480	1,301,798	6,308,679	1,035,301
Sulphured or foots.....	Lb.	40,822,557	3,233,242	40,299,635	3,306,753	39,562,342	3,451,716
Palm oil.....	Lb.	139,178,587	11,040,372	130,746,694	10,111,588	141,918,949	9,856,481
Peanut oil.....	Lb.	3,026,950	387,173	8,281,264	865,785	2,595,937	307,841
Linseed oil.....	Lb.	13,607,141	1,406,730	15,040,549	1,032,686	942,336	76,687
Soya bean oil.....	Lb.	19,492,900	1,507,219	30,711,687	2,150,923	14,894,327	885,932
Other vegetable oils, free.....	Lb.	10,386,298	1,331,920	7,481,721	936,067	5,423,407	597,077
duty.....	Lb.	1,471,585	161,487	13,886,700	1,467,742	2,007,742	199,674
Dyeing and tanning materials (vegetable)							
Logwood.....	Ton	22,788	402,923	24,926	509,898	29,973	540,207
Myrobalans.....	Ton	10,830	422,211	13,774	487,714	24,951	858,522
Quebrachowood.....	Ton	22,739	386,574	32,068	510,276	52,880	935,264
Sumac.....	Ton	2,856	346,411	3,871	303,509	4,267	249,976
Valonia.....	Lb.	19,735,139	343,963	19,412,890	332,456	9,456,589	223,124
Other crude.....	Lb.	59,946,443	1,327,381	66,660,579	1,308,630	69,783,156	1,388,324
Extracts for dyeing, etc.....	Lb.	3,817,305	340,310	2,373,117	229,255	1,213,812	124,120
Extracts for tanning							
Quebracho.....	Lb.	113,176,692	3,945,824	102,162,035	3,744,903	107,183,321	4,709,014
All other.....	Lb.	4,045,901	143,612	2,927,549	96,709	1,689,096	74,744
Starch.....	Lb.	12,778,414	535,462	23,181,116	807,388	27,466,291	1,061,518
Mineral oil							
Crude petroleum.....	Gal.	2,596,618,172	75,406,956	2,536,057,805	79,307,877	2,191,275,786	70,153,947
Tops and distillates.....	Gal.	8,812,744	661,345	34,565,994	2,632,708	3,834,768	337,822
Gasoline, naphthas.....	Gal.	160,137,182	15,978,296	232,662,677	24,553,008	198,255,666	21,430,011
Illuminating oil.....	Gal.	809,782	132,629	3,112,055	236,028	1,687,644	187,632
Lubricating oils.....	Gal.	1,573,949	286,387	1,386,740	266,641	314,076	92,751
Paraffin and paraffin wax.....	Lb.	14,588,124	1,003,385	9,983,104	651,714	18,556,072	1,084,530
Asphalt and bitumen.....	Ton	109,073	907,424	127,350	1,045,596	131,914	1,062,845
Lime and limestone crude.....	100 lb.	38,276,744	290,893	54,753,696	357,684	48,435,199	346,798
Kaolin, china and paper clay.....	Ton	332,622	3,195,527	353,746	3,483,550	274,587	2,666,414
Other clays.....	Ton	53,912	639,471	85,879	829,993	50,879	526,864
Chalk, unmanufactured.....	Ton	102,657	120,908	104,856	135,128	104,462	129,887
manufactured of.....	Lb.	17,762,670	160,707	23,034,071	154,850	2,810,208	85,289
Cryolite.....	Ton	9,844	690,651	7,687	657,598	5,063	410,802
Magnesite							
Crude or calcined.....	Lb.			30,876,887	336,686	18,996,870	211,255
Dead burned and grain.....	Lb.			154,215,473	1,128,823	89,880,413	656,361
Graphite.....	Lb.	35,559,145	828,082	32,387,194	923,513	32,695,145	531,833
Pyrites or sulphuret of iron.....	Ton	276,385	773,925	366,151	856,981	242,073	623,317
Talcum, steatite, French chalk.....	Lb.	41,980,365	449,338	48,692,369	563,799	46,986,139	509,996
Salt.....	100 lb.	160,021,407	319,783	121,958,925	215,009	91,094,827	158,504
Mineral wax.....	Lb.	6,175,184	361,767	8,286,497	479,957	6,862,328	531,833
Chrome ore.....	Lb.	149,739	1,207,420	214,944	1,711,347	203,674	1,574,522
Aluminum ore, crude bauxite.....	Ton	353,696	1,549,120	281,644	1,187,497	330,512	1,448,840
Antimony ore.....	Ton	2,718,238	47,084	5,102,530	290,858	6,422,306	249,442
Quicksilver.....	Lb.	1,708,560	1,321,586	2,146,076	1,936,458	1,705,890	1,997,346
Zinc dust.....	Lb.		58,655		45,974		87,290
Chemicals and allied products.....			128,339,989		134,735,457		119,497,505
Coal-tar chemicals (total).....			20,656,868		19,804,938		21,847,143
Coal-tar products, crude:							
Dead or creosote oil.....	Gal.	84,868,568	10,973,491	87,518,544	11,720,397	86,868,102	13,877,448
Pyridine.....	Lb.	789,077	394,337	743,283	366,161	135,692	42,021
Other crude coal-tar products.....			657,927		985,030		798,498
Intermediates							
Acids.....	Lb.	336,809	93,080	511,314	132,944	195,019	79,499
Other intermediate products.....	Lb.	2,240,564	1,004,792	998,290	642,212	1,677,327	982,999
Finished products							
Alizarin and derivatives.....	Lb.	47,583	74,635	21,454	37,986	4,165	2,583

Imports of Chemicals and Allied Products—Continued

		12 Months Ended December				11 Months Ended November	
		1925		1926		1927	
		Quantity	Value	Quantity	Value	Quantity	Value
Colors, dyes, stains, color acids, and color bases, n.e.s.	Lb.	5,785,465	\$7,166,335	4,972,949	\$5,600,655	5,139,309	\$5,732,024
Imported from							
Germany	Lb.	2,932,216	3,757,846	2,179,374	2,323,272	3,090,315	3,262,574
Switzerland	Lb.	1,972,416	2,261,822	1,864,891	2,171,317	1,389,733	1,707,077
United Kingdom	Lb.	170,443	144,621	200,912	202,642	139,730	141,510
Other countries	Lb.	710,390	1,002,046	727,772	903,424	519,531	620,863
Coal-tar medicinals	Lb.	107,889	253,349	70,033	256,062	114,576	255,165
Other finished coal-tar products	Lb.	13,599	38,922	23,026	63,491	40,420	76,906
Other chemicals							
Acids and anhydrides							
Arsenious acid or white arsenic	Lb.	18,631,387	1,076,073	15,417,913	511,211	24,088,745	864,216
Citric	Lb.	687,010	162,473	137,984	35,944	113,904	31,524
Formic	Lb.	1,487,149	105,155	2,315,308	164,045	3,027,084	218,025
Oxalic	Lb.	2,590,149	118,178	1,567,073	70,691	1,722,868	92,357
Sulphuric	Lb.	36,382,941	241,515	55,937,028	337,634	33,829,101	192,222
Tartaric	Lb.	3,580,253	702,183	1,564,692	329,773	2,587,139	579,370
All other	Free dut.	1,617,254	20,400	1,634,491	14,314	149,869	11,728
Alcohols, including fusel oil	Lb.	5,216,679	693,575	11,239,394	985,651	11,645,996	1,083,811
			734,837		356,974		798,644
Ammonia compounds, n.e.s.							
Muriate of ammonia	Lb.	10,990,274	462,129	15,811,876	617,191	13,519,178	483,968
Nitrate	Lb.	10,871,929	541,672	8,343,606	382,557	10,621,281	425,172
All other	Lb.	2,030,501	91,222	1,160,959	64,625	1,717,931	69,206
Barium compounds	Lb.	20,111,707	297,945	24,477,332	313,914	13,415,627	216,837
Cobalt oxide	Lb.	287,265	546,292	335,132	632,478	312,647	595,055
Copper sulphate	Lb.	1,805,095	92,930	2,558,584	117,269	1,587,326	70,541
Lime							
Chlorinated, or bleaching powder	Lb.	2,099,683	62,233	3,767,292	85,144	2,575,441	69,533
Citrate	Lb.	3,430,875	342,532	3,371,409	339,393	166,305	16,672
Glycerin	Lb.	21,292,301	2,540,747	38,444,416	6,327,132	21,978,692	3,728,326
Iodine, crude	Lb.	246,474	889,860	711,291	2,272,343	881,017	2,761,071
Potassium compounds							
Cyanide	Lb.	2,298,964	216,683	103,555	36,350	322,865	63,768
Carbonate	Lb.	7,895,425	348,174	11,523,391	533,840	12,000,203	562,920
Hydroxide	Lb.	12,256,971	733,849	12,913,783	767,476	13,401,776	878,826
Nitrate	Ton	8,396	447,717	9,416	526,573	3,241	213,845
Bitartrate, crude, argols	Lb.	24,665,695	1,689,758	25,625,400	1,794,466	23,455,428	2,140,921
Cream of tartar	Lb.	338,297	48,062	259,202	37,005	257,295	49,933
Potassium chlorate and perchlorate	Lb.	11,834,182	481,341	12,536,677	459,584	12,184,659	452,168
Other potassium compounds	Lb.	10,255,796	624,589	11,408,897	609,404	8,684,663	451,679
Sodium compounds							
Cyanide	Lb.	30,212,429	2,600,423	31,804,378	2,557,900	30,384,321	2,432,763
Ferrocyanide	Lb.	1,636,894	115,085	814,891	55,459	1,729,057	138,864
Nitrite	Lb.	1,971,105	78,149	1,927,189	69,575	252,869	9,376
All others, n.e.s.	Free dut.	15,026,201	188,908	21,735,767	196,619		284,331
	Free dut.		537,480		1,115,606		1,160,669
All other chemicals, n.e.s.	Free dut.		849,264		579,950		676,842
	Free dut.		2,998,055		3,228,221		3,815,817
Paints, pigments, and varnishes (total)			3,235,210		3,859,049		3,499,749
Mineral earth pigments							
Ochers and siennas	dut. Lb.	20,138,814	275,020	20,845,696	390,151	19,157,373	418,031
Other	dut. Lb.		934,821		1,147,626		1,083,786
Chemical pigments							
Zinc pigments	dut. Lb.	15,538,845	719,877	18,796,458	916,165	18,362,286	837,411
All other	dut. Lb.		735,094		585,603		467,447
Paints, stains and enamels	dut. Lb.	1,557,970	519,156	2,226,736	741,991	2,032,770	632,087
Varnishes	dut. Gal.	19,000	51,242	38,219	77,513	23,703	40,987
Fertilizers (total)	Ton	2,268,438	78,071,966	2,082,619	69,249,219	1,670,128	54,366,133
Nitrogenous							
Calcium cyanamid	Ton	97,954	4,689,438	88,373	4,193,123	98,072	3,918,779
Calcium nitrate	Ton	7,777	328,208	13,457	586,060	15,339	717,412
Sodium nitrate	Ton	1,112,226	52,530,877	914,295	42,781,386	682,236	27,986,025
Sulphate of ammonia	Ton	23,762	1,325,743	8,386	468,232	15,999	722,525
Guano	Ton	17,407	730,046	11,673	4,020,203	21,318	815,328
Dried blood	Ton	10,189	588,127	11,412	706,847	11,397	656,003
Tankage	Ton	30,060	1,018,207	24,568	1,009,391	21,889	821,192
Phosphate							
Bone phosphate	Ton	24,981	724,473	46,716	1,380,103	46,771	1,342,824
Other phosphate material	Ton	11,286	189,645	21,994	281,811	46,937	556,111
Potash fertilizers							
Chloride, crude (muriate of potash)	Ton	161,028	5,193,866	199,191	6,195,830	158,190	5,502,339
Sulphate, crude	Ton	68,952	2,686,408	69,873	2,823,438	62,383	2,680,115
Kainite	Ton	182,828	1,173,125	181,877	1,225,166	96,704	765,552
Manure salts	Ton	384,232	3,676,620	316,440	3,391,100	258,049	3,446,639
Other potash-bearing substances	Ton	23,597	320,889	48,333	497,545	9,147	237,194
All other fertilizers	Ton	39,367	955,501	54,299	754,578	38,530	787,826
Explosives							
Acides, fulminates, dynamite, etc., and powder from country imposing duty			184,769		207,609		162,826
Firecrackers	Lb.	4,188,368	850,787	3,685,924	795,123	4,233,226	790,378
Fireworks and ammunition	Lb.		68,270		162,548		94,162
Soap							
Castile	Lb.	1,823,541	230,236	2,021,096	245,845	2,239,428	344,422
Toilet	Lb.	1,088,716	384,515	1,219,148	409,218	1,530,316	524,161
All other	Lb.	2,579,652	305,984	3,090,924	318,309	1,730,813	175,559
Rubber and similar gums and manufactures of			552,221,466		640,449,073		326,213,024
Rubber, crude and milk of	Lb.	888,478,385	429,705,014	925,877,712	505,817,807	885,968,874	317,661,200
Jelutong	Lb.	15,118,547	1,642,531	16,268,345	3,127,757	16,673,223	2,388,310
Balata	Lb.	1,158,858	574,750	792,165	327,213	1,175,233	436,105
Gutta-percha	Lb.	3,591,081	629,284	3,236,704	661,156	3,273,657	712,077
Guayule	Lb.	8,469,123	1,803,448	9,643,131	2,562,096	10,407,378	2,479,877
Other crude	Lb.	25,458,639	983,406	31,928,633	1,483,179	19,184,236	816,127
Rubber belting	Lb.	748,580	559,908	731,827	488,486	598,475	365,764
Other manufactures	Lb.		1,298,197		1,328,488		1,282,671
Camphor							
Natural, crude	Lb.	2,369,413	1,301,032	2,018,971	1,157,923	1,689,714	810,304
Refined	Lb.	1,583,902	953,126	1,169,779	762,523	1,185,485	682,255
Synthetic	Lb.	1,834,988	920,936	2,944,478	1,558,006	2,610,875	3,135,351

Comparative Prices in New York Market, 1927

The following prices refer to round lots in the New York market. Where it is the trade custom to sell f.o.b. producing points, the quotations are given on that basis and are so designated. The figures show the opening price, the high, the low and the closing price for 1927.

Industrial Chemicals

	Jan. 1	High	Low	Dec. 31
Acetone, drums..... lb.	\$0.12	\$0.12	\$0.12	\$0.12
Acid, acetic, 28% bbl..... 100 lb.	3.38	3.38	3.38	3.38
Boric, bbl..... lb.	.08	.08	.08	.08
Citric, kegs..... lb.	.44	.46	.44	.44
Lactic, 44%, tech., light, bbl..... lb.	.13	.13	.13	.13
22% tech., light, bbl..... lb.	.06	.06	.06	.06
Muriatic, 18% tanks..... 100 lb.	.80	.85	.80	.85
Nitric, 36% carboys..... 100 lb.	5.00	5.00	5.00	5.00
Oxalic, crystals, bbl..... lb.	.10	.11	.10	.11
Sulphuric, 60% tanks..... tons	10.00	10.00	10.00	10.00
Tartaric, powd., bbl..... lb.	.27	.36	.27	.36
Alcohol, ethyl, 190 p.f. U.S.P., bbl..... gal.	4.90	4.90	3.70	3.70
Alcohol, denatured, 190 proof				
No. 1 special dr..... gal.	.31	.48	.31	.48
No. 3, 188 proof, dr..... gal.	.33	.48	.33	.48
Alum., ammonia, lump, bbl..... lb.	.03	.03	.03	.03
Potash, lump, bbl..... lb.	.02	.03	.02	.02
Aluminum sulphate, com., bags..... 100 lb.	1.35	1.40	1.35	1.35
Aqua ammonia, 26%, taps..... lb.	.02	.03	.02	.03
Ammonia, anhydrous, cyl..... lb.	.11	.13	.13	.13
Ammonium carbonate, powd. tech., casks..... lb.	.08	.08	.08	.08
Ammonium sulphate, wks..... 100 lb.	2.56	2.50	2.25	2.40
Amylacetate tech., drums..... gal.	1.60	2.15	1.60	1.75
Arsenic, white, powd., bbl..... lb.	.03	.04	.03	.04
Arsenic, red, powd., kegs..... lb.	.10	.10	.09	.09
Barium carbonate, bbl..... ton	48.00	53.00	47.00	50.00
Barium chloride, bbl..... ton	62.00	63.00	56.00	56.00
Barium, nitrate, casks..... lb.	.07	.08	.07	.08
Bleaching powd., f.o.b. wks., drums..... 100 lb.	2.00	2.00	2.00	2.00
Borax, bbl..... lb.	.04	.04	.04	.04
Calcium acetate, bags..... 100 lb.	3.50	3.50	3.50	3.50
Calcium arsenate, dr..... lb.	.06	.07	.05	.06
Calcium carbide, drums..... lb.	.05	.05	.05	.05
Calcium chloride, fused, dr., wks..... ton	21.00	21.00	21.00	21.00
Carbon bisulphide, drums..... lb.	.05	.05	.05	.05
Carbon tetrachloride, drums..... lb.	.06	.06	.06	.06
Chlorine, liquid, tanks, wks..... lb.	.04	.04	.04	.04
Cobalt, oxide bbl..... lb.	2.10	2.10	2.10	2.10
Copperas, bulk, f.o.b. wks..... ton	16.00	17.00	14.00	16.00
Copper carbonate, bbl..... lb.	.17	.17	.16	.17
Copper sulphate, bbl..... 100 lb.	.04	.05	.04	.05
Imp. bbl..... 100 lb.	.04	.05	.04	.05
Cream of tartar, bbl..... lb.	.21	.27	.21	.27
Epsom salt, dom., tea., bbl..... 100 lb.	1.50	1.75	1.50	1.75
Epsom salt, imp., tech., bags..... 100 lb.	1.25	1.25	1.15	1.15
Ethyl acetate, 85% drums..... gal.	.77	.77	.74	.74
Formaldehyde, 40%, bbl..... lb.	.11	.11	.08	.08
Fusel oil, crude, drums..... gal.	1.35	1.35	1.30	1.30
Glaucers salt, bags..... 100 lb.	1.10	1.10	1.00	1.00
Glycerine, c.p., drums, extra..... lb.	.30	.30	.20	.20
Lead:				
White, basic carbonate, dry, casks..... lb.	.09	.09	.09	.09
White, basic sulphate, casks..... lb.	.09	.09	.08	.08
Lead acetate, white ays., bbl..... lb.	.14	.14	.14	.14
Lead arsenate, powd., bbl..... lb.	.14	.14	.12	.12
Lithopone, bags..... lb.	.06	.06	.05	.05
Magnesium carb., tech., bags..... lb.	.06	.07	.06	.07
Methanol, 97%, dr..... gal.	.80	.80	.53	.53
Methanol, 97%, dr..... gla.	.82	.82	.55	.55
Nickel salts, double, bbl..... lb.	.10	.10	.10	.10
Nickel salts, single, bbl..... lb.	.10	.10	.10	.10
Phosphorus, red, cases..... lb.	.65	.65	.62	.62
Phosphorus, yellow, cases..... lb.	.32	.32	.32	.32
Potassium bichromate, casks..... lb.	.08	.08	.08	.08
Potassium carbonate, 80-85%, calcined, casks..... lb.	.05	.06	.05	.05
Potassium chlorate, powd..... lb.	.08	.08	.08	.08
Potassium hydroxide (caustic potash) drums..... ton	.07	.07	.07	.07
Potassium muriate, 80% bags..... 36.40	36.40	36.40	36.40	36.40
Potassium nitrate, bbl..... lb.	.06	.06	.06	.06
Potassium permanganate, drums..... lb.	.14	.15	.14	.15
Potassium persulfate, red, casks..... lb.	.38	.38	.36	.36
Potassium prussiate, yellow, casks..... lb.	.19	.19	.17	.18
Salammoniac, white, imp., casks..... lb.	.06	.06	.05	.05
Salsoda, bbl..... 100 lb.	.95	.95	.90	.90
Soda ash, light, 58% bags, contract 100 lb.	1.37	1.37	1.32	1.32
Soda, caustic, 76%, solid, drums, contract..... 100 lb.	3.00	3.00	2.80	2.80
Sodium acetate, works, bbl..... lb.	.04	.04	.04	.04
Sodium bicarbonate, 330-lb. bbl..... 100 lb.	2.00	2.00	2.00	2.00
Sodium bichromate, casks..... lb.	.06	.06	.06	.06
Sodium chlorate, kegs..... lb.	.06	.06	.06	.06
Sodium cyanide, cases, dom..... lb.	.20	.20	.20	.20
Sodium cyanide, imp. cases..... lb.	.19	.19	.18	.18
Sodium fluoride, bbl..... lb.	.11	.11	.08	.08
Sodium nitrate, bags..... 100 lb.	2.63	2.63	2.23	2.40
Sodium nitrite, casks..... lb.	.09	.09	.07	.07
Sodium phosphate, dibasic, bbl..... lb.	.03	.03	.03	.03
Sodium prussiate, yel. drums..... lb.	.10	.12	.10	.12

Industrial Chemicals—Continued

	Jan 1	High	Low	Dec. 31
Sodium silicate (40%, drums)..... 100 lb.	.75	.75	.75	.75
Sodium sulphide, fused, 60-62% drums..... 100 lb.	3.00	3.00	3.00	3.00
Sodium sulphite, crys., bbl..... lb.	.03	.03	.02	.03
Strontium nitrate, powd., bbl..... lb.	.09	.09	.07	.07
Sulphur, crude at mine, bulk..... ton	18.00	18.00	18.00	18.00
Tin bichloride, bbl..... lb.	.19	.20	.17	.17
Tin oxide, bbl..... lb.	.72	.72	.64	.64
Tin crystals, bbl..... lb.	.47	.47	.41	.41
Zinc chloride, gran., bbl..... lb.	.07	.07	.06	.06
Zinc oxide, lead free, bag..... lb.	.06	.06	.06	.06
5% lead sulphate, bags..... lb.	.06	.06	.06	.06
Zinc sulphate, bbl..... 100 lb.	3.00	3.00	2.75	.275

Coal-Tar Products

Alpha-naphthol, crude, bbl..... lb.	\$0.60	\$0.60	\$0.60	\$0.60
Alpha-naphthol, ref., bbl..... lb.	.80	.80	.80	.80
Alpha-naphthylamine, bbl..... lb.	.35	.35	.35	.35
Aniline oil, drums, extra..... lb.	.15	.16	.15	.15
Aniline salts, bbl..... lb.	.22	.24	.22	.24
Anthracene, 80%, drums..... lb.	.60	.60	.60	.60
Benzaldehyde, tech., carboys..... lb.	.65	.65	.65	.65
Benzene, 90%, tanks, works..... gal.	.24	.26	.24	.26
Benzidine base, bbl..... lb.	.70	.70	.70	.70
Benzoin acid, U.S.P., kegs..... lb.	.58	.60	.58	.60
Benzonate of soda, U.S.P., bbl..... lb.	.50	.50	.50	.50
Benzyl chloride, tech., drums..... lb.	.25	.30	.25	.30
Beta-naphthol, tech., bbl..... lb.	.22	.22	.22	.22
Beta-naphthylamine, tech..... lb.	.65	.65	.65	.65
Cresol, U.S.P., drums..... lb.	.17	.17	.17	.17
Cresylic acid, 97%, drums, works..... gal.	.68	.74	.68	.74
95-97%, drums, works..... gal.	.58	.72	.58	.72
Diethylaniline, drums..... lb.	.58	.58	.55	.55
Dimethylaniline, drums..... lb.	.32	.32	.31	.31
Dinitrophenol, bbl..... lb.	.31	.31	.30	.30
Dinitrotoluene, bbl..... lb.	.18	.18	.18	.18
Diphenylamine, bbl..... lb.	.45	.45	.42	.42
H-acid, bbl..... lb.	.60	.68	.60	.68
Monochlorobenzene, drums..... lb.	.07	.10	.07	.10
Monethylaniline, drums..... lb.	1.05	1.05	1.05	1.05
Naphthalene, flake, bbl..... lb.	.04	.05	.04	.05
Naphthalene, balls, bbl..... lb.	.05	.05	.05	.05
Naphthionate of soda, bbl..... lb.	.51	.55	.51	.55
Naphthionie acid, crude, bbl..... lb.	.55	.55	.55	.55
Nitrobenzene, drums..... lb.	.09	.10	.09	.09
N-W acid, bbl..... lb.	.95	.95	.95	.95
Ortho-aminophenol, kegs..... lb.	2.15	2.15	2.15	2.15
Ortho-dichlorobenzene, drums..... lb.	.09	.09	.08	.08
Ortho-nitrophenol, bbl..... lb.	.85	.85	.85	.85
Ortho-toluidine, bbl..... lb.	.25	.25	.25	.25
Para-aminophenol, base, kegs..... lb.	1.15	1.15	1.00	1.00
Para-dichlorobenzene, bbl..... lb.	.21	.21	.17	.18
Para-nitroaniline, bbl..... lb.	.52	.52	.52	.52
Para-nitrotoluene, bbl..... lb.	.30	.30	.28	.28
Para-phenylenediamine, bbl..... lb.	1.25	1.25	1.20	1.20
Para-toluidine, bbl..... lb.	.49	.49	.40	.40
Phthalic anhydride, bbl..... lb.	.25	.25	.18	.18
Phenol, U.S.P., dr..... lb.	.17	.17	.17	.17
Picric acid, bbl..... lb.	.30	.40	.30	.40
Resorcinol, tech., kegs..... lb.	1.25	1.25	1.25	1.25
R-salt, bbl..... lb.	.45	.46	.45	.45
Salicylic acid, tech., bbl..... lb.	.38	.38	.37	.37
Salicylic acid, U.S.P., bbl..... lb.	.40	.40	.40	.40
Solvent naphtha, crude, tanks..... gal.	.35	.35	.35	.35
Sulphanilic acid, crude, bbl..... lb.	.16	.16	.15	.15
Toluidine, mixed, kegs..... lb.	.30	.32	.30	.31
Toluene, tank cars, works..... gal.	.35	.40	.35	.40
Xylidine, drums..... lb.	.38	.38	.37	.37
Xylene, 5%, drums..... gal.	.45	.50	.45	.50
Xylene, com., tanks..... gal.	.36	.36	.36	.36

Oils and Fats

Castor oil, No. 3, bbl..... lb.	\$0.12	\$0.14	\$0.12	\$0.13
Chinawood oil, bbl..... lb.	.13	.33	.13	.14
Coconut oil, Ceylon, tanks, N. Y..... lb.	.09	.09	.08	.08
Corn oil, crude, tanks (f.o.b. mill)..... lb.	.07	.11	.07	.09
Cottonseed oil, crude (f.o.b. mill), tanks lb.	.06	.09	.06	.08
Linseed oil, raw, car lots, bbl..... lb.	.103	.112	.094	.096
Palm, Lagos, casks..... lb.	.08	.08	.07	.07
Niger, casks..... lb.	.07	.08	.07	.07
Peanut oil, crude, tanks (mill)..... lb.	.10	.12	.09	.09
Rapeseed oil, refined, bbl..... gal.	.79	.85	.77	.80
Soya bean tanks (f.o.b. coast)..... lb.	.10	.11	.09	.09
Sulphur (olive foots), bbl..... lb.	.09	.10	.09	.09
Cod, Newfoundland, bbl..... gal.	.63	.63	.63	.63
Menhaden, light pressed, bbl..... gal.	.62	.62	.60	.60
Crude, tanks (f.o.b. factory)..... gal.	.45	.47	.44	.44
Grease, yellow, loose..... lb.	.06	.07	.06	.06
Oleo Stearine..... lb.	.09	.12	.08	.10
Red oil, distilled, d.p. bbl..... lb.	.09	.10	.09	.09
Tallow, extra, loose..... lb.	.07	.08	.07	.08

Miscellaneous

Paraffine wax, crude, 124 m.p. bg..... ab.	\$0.05	\$0.05	\$0.02	\$0.02
Rooin, H, bbl..... 100 lb.	12.25	12.25	8.35	9.25
Turpentine, spirits, bbl..... gal.	.85	.85	.47	.55

CURRENT PRICES in the NEW YORK MARKET

For Chemicals, Oils and Allied Products

The following prices refer to round lots in the New York Market. Where it is the trade custom to sell f.o.b. works, quotations are given on that basis and are so designated. Prices are corrected to January 16.

Industrial Chemicals

	Current Price	Last Month	Last Year
Acetone, drums.....lb.	\$0.13 - \$0.14	\$0.12 - \$0.13	\$0.12 - \$0.13
Acid, acetic, 28%, bbl.....cwt.	3.38 - 3.63	3.38 - 3.63	3.25 - 3.50
Boric, bbl.....lb.	.081 - .084	.081 - .084	.081 - .11
Citric, kegs.....lb.	.44 - .45	.44 - .45	.45 - .47
Formic, bbl.....lb.	.11 - .12	.10 - .11	.10 - .11
Gallie, tech., bbl.....lb.	.50 - .55	.50 - .55	.45 - .50
Hydrofluoric 30% carb. lb.	.06 - .07	.06 - .07	.06 - .07
Lactic, 44%, tech., light, bbl. lb.	.13 - .14	.13 - .14	.13 - .14
22%, tech., light, bbl. lb.	.06 - .07	.06 - .07	.06 - .07
Muriatic, 18%, tanks.....cwt.	.85 - .90	.85 - .90	.85 - .90
Nitric, 36%, carboys.....lb.	.05 - .051	.05 - .051	.05 - .051
Oleum, tanks, wks.....ton	18.00 - 20.00	18.00 - 20.00	18.00 - 20.00
Oxalic, crystals, bbl.....lb.	.11 - .111	.11 - .111	.10 - .11
Phosphoric, tech., c'bye.....lb.	.081 - .09	.081 - .09	.07 - .071
Sulphuric, 60%, tanks.....ton	10.50 - 11.00	10.50 - 11.00	10.50 - 11.00
Tannic, tech., bbl.....lb.	.35 - .40	.35 - .40	.35 - .40
Tartaric, powd., bbl.....lb.	.36 - .371	.36 - .371	.29 - .30
Tungstic, bbl.....lb.	1.00 - 1.20	1.00 - 1.20	1.00 - 1.20
Alcohol, ethyl, 190 n'l., bbl. gal.	2.701 - 2.75	2.701 - 2.75	2.75 - 3.00
Alcohol, Butyl, dr.....lb.	.19 - .201	.19 - .201	.18 - .19
Denatured, 190 proof			
No. 1 special dr.....gal.	.48 - .49	.48 - .49	.31 - .32
No. 5, 188 proof, dr.....gal.	.48 - .49	.48 - .49	.31 - .32
Alum, ammonia, lump, bbl.....lb.	.031 - .04	.031 - .04	.031 - .04
Chrome, bbl.....lb.	.051 - .051	.051 - .051	.051 - .06
Potash, lump, bbl.....lb.	.021 - .031	.021 - .031	.021 - .031
Aluminum sulphate, com., bags			
Iron free, bg.....cwt.	1.40 - 1.45	1.40 - 1.45	1.40 - 1.45
Aqua ammonia, 26%, drums.....lb.	2.00 - 2.10	2.00 - 2.10	2.00 - 2.10
Ammonia, anhydrous, cyl. lb.	.03 - .04	.021 - .031	.031 - .04
Ammonium carbonate, powd. tech., casks.....lb.	.131 - .14	.131 - .14	.13 - .15
Sulphate, wks.....cwt.	1.01 - .14	1.01 - .14	.11 - .14
Amylacetate tech., drums.....gal.	2.40 - 2.60	2.40 - 2.60	2.50 - 2.60
Antimony Oxide, bbl.....lb.	1.75 - 2.00	2.15 - 2.20	1.80 - 1.90
Arsenic, white, powd., bbl.....lb.	.15 - .161	.16 - .171	.141 - .15
Red, powd., kegs.....lb.	.04 - .041	.04 - .041	.031 - .041
Barium carbonate, bbl.....ton	.091 - .10	.091 - .10	.11 - .12
Chloride, fused, dr., wks.....ton	50.00 - 52.00	50.00 - 52.00	48.00 - 50.00
Nitrate, casak.....lb.	56.00 - 58.00	58.00 - 60.00	63.00 - 65.00
Blanc fixe, dry, bbl.....lb.	.08 - .081	.08 - .081	.071 - .08
Bleaching powder, f.o.b., wks. drums.....cwt.	.04 - .041	.04 - .041	.04 - .041
Borax, bbl.....lb.	2.00 - 2.10	2.00 - 2.10	2.00 - 2.10
Bromine, cas.....lb.	.04 - .041	.041 - .05	.05 - .051
Calcium acetate, bags.....cwt.	.45 - .47	.45 - .47	.45 - .47
Arsenate, dr.....cwt.	3.50 - 3.50	3.50 - 3.50	3.25 - 3.50
Carbide, fused, dr., wks.....ton	.071 - .07	.071 - .08	.071 - .08
Chloride, fused, dr., wks.....ton	.05 - .06	.05 - .06	.05 - .06
Phosphate, bbl.....lb.	21.00 - 21.00	21.00 - 21.00	21.00 - 21.00
Carbon bisulphide, drums.....lb.	.07 - .071	.07 - .071	.07 - .071
Tetrachloride, drums.....lb.	.051 - .06	.051 - .06	.051 - .06
Chlorine, liquid, tanks, wks.....lb.	.061 - .07	.061 - .07	.061 - .07
Cylinders.....lb.	.031 - .041	.04 - .041	.04 - .041
Cobalt oxide, cans.....lb.	.051 - .08	.051 - .08	.051 - .08
Copperas, bags, f.o.b. wks.....ton	2.00 - 2.10	2.00 - 2.10	2.10 - 2.25
Copper carbonate, bbl.....lb.	14.00 - 17.00	14.00 - 17.00	13.00 - 15.00
Sulphate, bbl.....lb.	.17 - .171	.17 - .18	.161 - .17
Cyanide, tech., bbl.....lb.	.49 - .50	.49 - .50	.49 - .50
Sulphate, bbl.....cwt.	5.00 - 5.10	5.00 - 5.10	4.90 - 5.00
Cream of tartar, bbl.....lb.	.251 - .27	.271 - .28	.21 - .22
Diethylene glycol, dr.....gal.	.15 - .20	.15 - .20	.15 - .20
Epsom salt, dom., tech., bbl. cwt.	1.75 - 2.15	1.75 - 2.00	1.75 - 2.00
Imp., tech., bags.....cwt.	1.15 - 1.25	1.15 - 1.25	1.35 - 1.40
Ethyl acetate, 85% drums.....gal.	.74 - .76	.74 - .76	.74 - .76
Formaldehyde, 40%, bbl.....lb.	.081 - .081	.081 - .111	.09 - .091
Furfural, dr.....lb.	.15 - .171	.15 - .171	.15 - .17
Fusel oil, crude, drums.....gal.	1.30 - 1.40	1.30 - 1.40	1.40 - 1.50
Refined, dr.....gal.	2.50 - 3.00	2.50 - 3.00	2.50 - 3.00
Glauber salt, bags.....cwt.	1.10 - 1.20	1.00 - 1.10	1.20 - 1.40
Glycerine, c.p., drums, extra. lb.	.211 - .22	.23 - .24	.30 - .30
Lead:			
White, basic carbonate, dry, casks.....lb.	.081 - .09	.09 - .101	.101 - .101
White, basic sulphate, sek. lb.	.071 - .081	.081 - .091	.091 - .091
Red, dry, sek.....lb.	.10 - .10	.10 - .111	.111 - .111
Lead acetate, white crys., bbl. lb.	.13 - .131	.131 - .131	.14 - .14
Lead arsenate, powd., bbl. lb.	.12 - .13	.12 - .13	.14 - .15
Lime, chem., bulk.....ton	8.50 - 8.50	8.50 - 8.50	8.50 - 8.50
Litharge, powd., casak.....lb.	.09 - .09	.09 - .101	.101 - .101
Lithopone, bags.....lb.	.051 - .06	.051 - .06	.051 - .061
Magnesium carb., tech., bags. lb.	.071 - .08	.071 - .08	.061 - .061
Methanol, 95%, dr.....gal.	.53 - .55	.53 - .55	.75 - .75
97%, dr.....gal.	.55 - .55	.55 - .55	.77 - .77
Nickel salt, double, bbl.....lb.	.10 - .101	.10 - .101	.09 - .10
Single, bbl.....lb.	.101 - .11	.101 - .11	.10 - .11

	Current Price	Last Month	Last Year
Orange mineral, cask.....lb.	\$0.12 -	\$0.12 -	\$0.131 -
Phosphorus, red, cases.....lb.	.62 - \$0.65	.62 - \$0.65	.65 - \$0.68
Yellow, cases.....lb.	.32 - .33	.32 - .34	.33 - .34
Potassium bichromate, casks. lb.	.081 - .081	.081 - .081	.081 - .081
Carbonate, 80-85%, calc., cask. lb.	.051 - .06	.051 - .06	.061 - .061
Chlorate, powd.....lb.	.081 - .09	.081 - .09	.081 - .09
Cyanide, cas.....lb.	.55 - .57	.55 - .58	.55 - .57
First sort, cask.....lb.	.09 - .091	.081 - .09	.081 - .09
Hydroxide (caustic potash) dr. lb.	.071 - .071	.071 - .071	.071 - .071
Muriate, 80% bgs.....ton	36.40 -	36.40 -	36.00 -
Nitrate, bbl.....lb.	.06 - .061	.06 - .061	.06 - .071
Permanganate, drums.....lb.	.15 - .16	.14 - .15	.141 - .15
Prussiate, yellow, casks.....lb.	.18 - .19	.181 - .19	.18 - .19
Salt ammoniac, white, casks. lb.	.047 - .05	.05 - .051	.051 - .06
Salaoda, bbl.....cwt.	.90 - .95	.90 - .95	.90 - .95
Salt cake, bulk.....ton	17.00 - 18.00	17.00 - 18.00	17.00 - 19.00
Soda ash, light, 58%, bags, contract.....cwt.	1.32 -	1.321 -	1.38 -
Dense, bags.....cwt.	1.35 -	1.371 - 1.55	1.45 - 1.55
Soda, caustic, 76%, solid, drums, contract.....cwt.	2.80 - 3.00	3.00 -	3.10 -
Acetate, works, bbl.....lb.	.041 - .051	.041 - .05	.041 - .05
Bicarbonate, bbl.....cwt.	2.00 - 2.25	2.00 - 2.25	2.00 - 2.25
Bichromate, casks.....lb.	.061 - .061	.061 - .061	.061 - .061
Bisulphate, bulk.....ton	3.00 - 3.50	5.00 - 5.50	6.00 - 7.00
Bisulphite, bbl.....lb.	.031 - .04	.031 - .04	.031 - .04
Chlorate, kegs.....lb.	.061 - .061	.061 - .061	.061 - .061
Chloride, tech.....ton	12.00 - 14.75	12.00 - 14.75	12.00 - 14.00
Cyanide, cases, dom.....lb.	.18 - .22	.18 - .22	.19 - .22
Fluoride, bbl.....lb.	.081 - .09	.081 - .09	.081 - .09
Hyposulphite, bbl.....lb.	2.50 - 3.00	2.50 - 3.00	2.65 - 3.00
Nitrate, bags.....cwt.	2.40 -	2.30 -	2.36 -
Nitrite, casks.....lb.	.081 - .081	.081 - .081	.081 - .09
Phosphate, dibasic, bbl.....lb.	.03 - .031	.031 - .031	.031 - .031
Prussiate, yel. drums.....lb.	.12 - .121	.12 - .121	.10 - .101
Silicate (30%, drums).....cwt.	.75 - 1.15	.75 - 1.15	.75 - 1.15
Sulphate, fused, 60-62%, dr. lb.	.031 - .04	.031 - .04	.021 - .03
Sulphite, crys., bbl.....lb.	.03 - .031	.03 - .031	.021 - .03
Strontium nitrate, bbl.....lb.	.09 - .091	.081 - .09	.081 - .09
Sulphur, crude at mine, bulk. ton	18.00 -	18.00 -	18.00 -
Chloride, dr.....lb.	.04 - .05	.04 - .05	.05 - .051
Dioxide, cyl.....cwt.	.09 - .10	.09 - .10	.09 - .10
Flour, bag.....lb.	2.70 - 3.00	2.70 - 3.00	2.70 - 3.00
Tin bichloride, bbl.....lb.	.171 -	.171 -	.19 -
Oxide, bbl.....lb.	.62 -	.64 -	.67 -
Crystals, bbl.....lb.	.41 -	.42 -	.48 -
Zinc chloride, gran., bbl.....lb.	.061 - .061	.061 - .061	.07 - .071
Carbonate, bbl.....lb.	.10 - .11	.10 - .101	.101 - .11
Cyanide, dr.....lb.	.40 - .41	.40 - .41	.40 - .41
Dust, bbl.....lb.	.09 - .10	.101 - .11	.09 - .10
Zinc oxide, lead free, bag. lb.	.061 -	.061 -	.071 -
5% lead sulphate, bags.....lb.	.061 -	.061 -	.071 -
Sulphate, bbl.....cwt.	2.75 - 3.00	2.75 - 3.00	2.75 - 3.00

Oils and Fats

	Current Price	Last Month	Last Year
Castor oil, No. 3, bbl.....lb.	\$0.13 - \$0.131	\$0.13 - \$0.131	\$0.121 - \$0.13
China wood oil, bbl.....lb.	.18 -	.15 -	.141 -
Coconut oil, Ceylon, tanks, N. Y.....lb.	.081 -	.081 -	.081 -
Corn oil crude, tanks, (f.o.b. mill).....lb.	.091 -	.091 -	.07 -
Cottonseed oil, crude (f.o.b. mill), tanks.....lb.	.081 -	.081 -	.07 -
Linseed oil, raw, car lots, bbl. lb.	.098 -	.096 -	.105 -
Palm, Lagon, casks.....lb.	.08 -	.08 -	.081 -
Niger, casks.....lb.	.071 -	.071 - .071	.071 -
Palm Kernel, bbl.....lb.	.09 -	.09 -	.09 -
Peanut oil, crude, tanks (mill) lb.	.091 -	.091 -	.13 -
Perilla, bbl.....lb.	.82 -	.85 -	.79 -
Rapeseed oil, refined, bbl. gal.	.82 - .84	.85 - .86	.79 - .80
Sesame, bbl.....lb.	.091 -	.091 -	.091 -
Soy bean tank (f.o.b. Coast) lb.	.10 -	.10 -	.091 -
Sulphur (olive foots), bbl.....lb.	.63 - .62	.63 - .64	.63 - .65
Cod, Newfoundland, bbl.....gal.	.60 - .66	.60 - .62	.58 - .60
Menhaden, light pressed, bbl. gal.	.44 -	.44 -	.45 -
Crude, tanks (f.o.b. factory) gal.	.44 -	.44 -	.45 -
Whale, crude, tanks.....lb.	.071 -	.071 -	.061 -
Grease, yellow, loose.....lb.	.101 -	.101 -	.081 -
Oleo stearine.....lb.	.091 - .091	.091 - .10	.091 - .10
Red oil, distilled, d.p. bbl.....lb.	.081 -	.081 -	.071 -
Tallow, extra, loose.....lb.	.081 -	.081 -	.071 -

Coal-Tar Products

	Current Price	Last Month	Last Year
Alpha-naphthol, crude, bbl. lb.	\$0.60 - \$0.65	\$0.60 - \$0.65	\$0.60 - \$0.62
Refined, bbl.....lb.	.85 - .90	.85 - .90	.85 - .90
Alpha-naphthylamine, bbl. lb.	.35 - .36	.35 - .36	.35 - .36
Aniline oil, drums, extra.....lb.	.15 - .16	.15 - .16	.16 - .161
Aniline salts, bbl.....lb.	.24 - .25	.24 - .25	.22 - .23
Anthracene, 80%, drums.....lb.	.60 - .65	.60 - .65	.60 - .65

Coal Tar Products (Continued)

	Current Price	Last Month	Last Year
Benzaldehyde, U.S.P., dr. . . lb.	1.15 - 1.25	1.15 - \$1.35	1.30 - 1.35
Benzidine base, bbl. . . lb.	.70 - .72	.70 - .75	.72 - .74
Benzoic acid, U.S.P., kgs. . . lb.	.58 - .60	.58 - .60	.56 - .60
Benzyl chloride, tech, dr. . . lb.	.25 - .26	.25 - .26	.25 - .26
Benzol, 90%, tanks, works. gal.	.24 - .25	.24 - .25	.24 - .25
Beta-naphthol, tech., drums. lb.	.22 - .24	.22 - .24	.22 - .24
Cresol, U.S.P., dr. . . lb.	.18 - .20	.18 - .20	.18 - .20
Crocylic acid, 97%, dr., wks. gal.	.61 - .62	.61 - .62	.60 - .65
Diethylaniline, dr. . . lb.	.58 - .60	.58 - .60	.58 - .60
Dinitrophenol, bbl. . . lb.	.31 - .35	.31 - .33	.31 - .35
Dinitrotoluene, bbl. . . lb.	.17 - .18	.17 - .18	.18 - .20
Dip oil, 25% dr. . . gal.	.28 - .30	.28 - .30	.28 - .30
Diphenylamine, bbl. . . lb.	.45 - .47	.45 - .47	.48 - .50
H-acid, bbl. . . lb.	.63 - .65	.63 - .65	.65 - .66
Naphthalene, flake, bbl. . . lb.	.04 - .05	.04 - .05	.06 - .07
Nitrobenzene, dr. . . lb.	.09 - .10	.09 - .10	.09 - .10
Para-nitraniline, bbl. . . lb.	\$0.52 - \$0.53	\$0.52 - \$0.53	\$0.50 - \$0.53
Para-nitrotoluene, bbl. . . lb.	.28 - .32	.28 - .32	.40 - .42
Phenol, U.S.P., drums. . . lb.	.18 - .19	.18 - .19	.17 - .18
Picric acid, bbl. . . lb.	.30 - .40	.30 - .40	.25 - .26
Pyridine, dr. . . lb.	3.00 - . . .	3.00 - . . .	3.90 - 4.00
R-salt, bbl. . . lb.	.47 - .50	.47 - .50	.50 - .55
Resorcinol, tech., wks. gal.	1.30 - 1.35	1.35 - 1.40	1.30 - 1.40
Salicylic acid, tech., bbl. . . lb.	.30 - .32	.30 - .32	.32 - .33
Solvent naphtha, w.w., tanks. gal.	.35 - . . .	.35 - . . .	.35 - . . .
Tolidine, bbl. . . lb.	.95 - .95	.95 - .96	.90 - .95
Toluene, tanks, works. . . gal.	.35 - . . .	.35 - . . .	.35 - . . .
Xylene, com., tanks. . . gal.	.36 - .41	.36 - .41	.36 - .40

Miscellaneous

	Current Price	Last Month	Last Year
Barytes, grd., white, bbl. . . ton	\$23.00 - \$25.00	\$23.00 - \$25.00	\$23.00 - \$25.00
Casein, tech., bbl. . . lb.	.17 - .18	.17 - .18	.16 - .17
China clay, dom. f.o.b. mine ton	10.00 - 20.00	10.00 - 20.00	10.00 - 20.00
Dry colors:			
Carbon gas, black (wks.) . . lb.	.06 - .07	.06 - .07	.08 - .08
Prussian blue, bbl. . . lb.	.31 - .33	.31 - .33	.32 - .33
Ultramarine blue, bbl. . . lb.	.08 - .35	.08 - .35	.08 - .35
Chrome green, bbl. . . lb.	.27 - .31	.27 - .31	.28 - .30
Carmine green, tins. . . lb.	5.50 - 5.75	5.50 - 5.75	5.10 - 5.85
Para toner. . . lb.	.70 - .80	.70 - .80	.90 - .95
Vermilion, English, bbl. . . lb.	1.80 - 1.85	1.80 - 1.85	1.45 - 1.50
Chrome yellow, C. P., bbl. lb.	.17 - .18	.17 - .18	.17 - .18
Feldspar, No. 1 (f.o.b. N. C.) ton	5.75 - 7.00	5.75 - 7.00	6.00 - 6.50
Graphite, Ceylon, lump, bbl. lb.	.07 - .08	.07 - .08	.09 - .10
Gum copal, Congo, bags. . . lb.	.15 - .18	.15 - .16	.14 - .10
Manila, bags. . . lb.	.48 - .54	.48 - .54	.53 - .25
Damar, Batavia, cases. . . lb.	.48 - .54	.48 - .54	.53 - .56
Kauri, No. 1 cases. . . lb.	.48 - .54	.48 - .54	.53 - .56
Kieselguhr (f.o.b. N. Y.) . . ton	50.00 - 55.00	50.00 - 55.00	50.00 - 55.00
Magnesite, calc. . . ton	44.00 - . . .	44.00 - . . .	38.00 - 42.00
Fumic stone, lump, bbl. . . lb.	.05 - .07	.05 - .08	.04 - .06
Imported, cases. . . lb.	.03 - .40	.03 - .40	.03 - .35
Rosin, H. . . bbl.	10.30 - . . .	8.50 - . . .	12.25 - . . .
Turpentine. . . gal.	.63 - . . .	.56 - . . .	.68 - . . .
Shellac, orange, fine, bags. . lb.	.56 - .59	.59 - .61	.49 - .51
Bleached, bonedry, bags. . lb.	.59 - .61	.61 - .63	.53 - .55
T. N. bags. . . lb.	.52 - .54	.55 - .57	.44 - .46
Soapstone (f.o.b. Vt.), bags. ton	10.00 - 12.00	10.00 - 12.00	9.00 - 11.00
Talc, 200 mesh (f.o.b. Vt.) . . ton	10.50 - . . .	10.50 - . . .	10.50 - . . .
200 mesh (f.o.b. Ga.) . . ton	7.50 - 10.00	7.50 - 10.00	7.50 - 11.00
325 mesh (f.o.b. N. Y.) . . ton	13.75 - . . .	13.75 - . . .	14.75 - . . .

	Current Price	Last Month	Last Year
Wax, Bayberry, bbl. . . lb.	\$0.23 - \$0.24	\$0.22 - \$0.25	\$0.25 - \$0.26
Beeswax, ref., light. . . lb.	.43 - .45	.43 - .47	.46 - .47
Candelilla, bags. . . lb.	.27 - .28	.27 - .28	.34 - .35
Carnauba, No. 1, bags. . . lb.	.55 - .60	.55 - .60	.70 - .72
Paraffine, crude 105-110 m.p. . . lb.	.04 - .05	.04 - .05	.05 - .06

Ferro-Alloys

	Current Price	Last Month	Last Year
Ferrotitanium, 15-18% . . . ton	\$200.00 - . . .	\$200.00 - . . .	\$200.00 - . . .
Ferromanganese, 78-82% . . ton	100.00 - . . .	100.00 - . . .	88.00 - 90.00
Spiegeleisen, 19-21% . . . ton	30.00 - 31.00	30.00 - 31.00	33.00 - 34.00
Ferrosilicon, 10-12% . . . ton	33.00 - 38.00	33.00 - 38.00	33.00 - 38.00
Ferrotungsten, 70-80% . . . lb.	.95 - 1.00	.95 - 1.00	1.05 - 1.10
Ferro-uranium, 35-50% . . . lb.	4.50 - . . .	4.50 - . . .	4.50 - . . .
Ferrovanadium, 30-40% . . . lb.	3.15 - 3.75	3.15 - 4.00	3.25 - 3.75

Non-Ferrous Metals

	Current Price	Last Month	Last Year
Copper, electrolytic. . . lb.	\$0.13 - . . .	\$0.13 - . . .	\$0.14 - . . .
Aluminum, 96-99% . . . lb.	.25 - .26	.26 - .27	.27 - .28
Antimony, Chin. and Jap. . . lb.	.10 - .11	.11 - .11	.13 - .13
Nickel, 99% . . . lb.	.35 - . . .	.35 - . . .	.35 - . . .
Monel metal, blocks. . . lb.	.32 - .33	.32 - .33	.32 - .33
Tin, 5-ton lots, Straits. . . lb.	.58 - . . .	.56 - . . .	.64 - . . .
Lead, New York, spot. . . lb.	6.50 - . . .	6.25 - . . .	8.40 - . . .
Zinc, New York, spot. . . lb.	6.15 - . . .	5.95 - . . .	7.65 - . . .
Silver, commercial. . . oz.	.57 - . . .	.57 - . . .	.63 - . . .
Cadmium. . . lb.	.60 - . . .	.60 - . . .	.60 - . . .
Bismuth, ton lots. . . lb.	1.85 - 2.10	1.85 - 2.00	2.70 - 2.75
Cobalt. . . lb.	2.50 - . . .	2.50 - . . .	3.00 - . . .
Magnesium, ingots, 99% . . lb.	.75 - .80	.75 - .80	.75 - .80
Platinum, ref. . . oz.	72.00 - . . .	72.00 - . . .	111.00 - . . .
Palladium, ref. . . oz.	50.00 - 52.00	52.00 - 53.00	68.00 - 70.00
Mercury, flask. . . 75 lb.	124.00 - . . .	128.00 - . . .	101.00 - . . .
Tungsten powder. . . lb.	1.05 - 1.15	1.05 - . . .	1.10 - . . .

Ores and Semi-finished Products

	Current Price	Last Month	Last Year
Bauxite, crushed, wks. . . ton	\$5.50 - \$8.50	\$5.50 - \$8.50	\$5.50 - \$8.75
Chrome ore, c.f. post. . . ton	22.00 - 24.00	22.00 - 24.00	22.00 - 23.00
Coke, fdry., f.o.b. ovens. . . ton	3.75 - 4.25	3.75 - 4.25	3.75 - 4.25
Fluorspar, gravel, f.o.b. Ill. . . ton	17.00 - 18.00	17.00 - . . .	18.00 - . . .
Ilmenite, 52% TiO ₂ , Va. . . lb.	.00 - .00	.00 - .00	.01 - . . .
Manganese ore, 50% Mn., c.f. Atlantic Ports. . . unit	.36 - .38	.36 - .38	.40 - .42
Molybdenite, 85% MoS ₂ , per lb. MoS ₂ , N. Y. . . lb.	.48 - .50	.48 - .50	.65 - .70
Monazite, 6% of ThO ₂ . . . ton	120.00 - . . .	120.00 - . . .	120.00 - . . .
Pyrites, Span. fines, c.f. . . unit	.13 - . . .	.13 - . . .	.13 - . . .
Rutile, 94-96% TiO ₂ . . . lb.	.11 - .13	.11 - .13	.12 - .15
Tungsten, scheelite. . . lb.	. . . - - - . . .
60% WO ₃ and over. . . unit	10.50 - 10.75	10.35 - 10.50	11.00 - 11.25
Vanadium ore, per lb. V ₂ O ₅ . . lb.	.25 - .28	.25 - .30	.30 - .35
Zircon, 99% . . . lb.	.03 - . . .	.03 - . . .	.03 - . . .

Patents Issued, Nov. 29 to Dec. 27, 1927

RUBBER AND SYNTHETIC PLASTICS

Art of Vulcanizing Rubber. Clayton W. Bedford, Akron, Ohio, assignor to The B. F. Goodrich Company, New York, N. Y.—1,650,975.

Process for Compounding and Vulcanizing Rubber and Products Obtained Therefrom. Omar H. Smith, New York, N. Y., assignor to The Naugatuck Chemical Company, Naugatuck, Conn.—1,651,737.

Rubber-Vulcanization Accelerator. Clayton Olin North, Tallmadge Township, Summit County, Ohio, assignor to The Rubber Service Laboratories Co., Akron, Ohio.—1,651,931.

Process for The Vulcanization of Caoutchouc. Stanley John Peachey, London, and Allan Skipsey, Woking, England.—1,653,821.

PETROLEUM REFINING

Process of and Apparatus for Refining Petroleum and Oil-Field Emulsions. Louis E. Winkler and Fred C. Koch, Wichita, Kans.—1,650,813.

Art of Manufacturing Gas From Petroleum Oil. Edgar M. Clark, New York, N. Y., and Nathaniel E. Loomis and Frank A. Howard, Elizabeth, N. J., assignors to Standard Development Company.—1,651,115.

Process for Converting Petroleum Oils. Carbon P. Dubbs, Wilmette, Ill., assignor to Universal Oil Products Company, Chicago, Ill.—1,652,166.

Method and Apparatus for Cracking Oils. William Brink, Henryetta, Okla.—1,652,344.

Apparatus for Treating Hydrocarbons and Other Materials. David E. De Lape, Los Angeles, Calif.—1,652,563.

Coking Hydrocarbon Oils. Robert E. Wilson, Chicago, Ill., and Harold V. Atwell, Whiting, Ind., assignors to Standard Oil Company, Whiting, Ind.—1,654,200.

ORGANIC PROCESSES

Process of Gas Manufacture. Willis Stuart Yard and Earl Newman Percy, Oakland, Calif.—1,649,640.

Synthetic Resin Composition. Howard L. Bender, Bloomfield, N. J., assignor to Bakelite Corporation, New York, N. Y.—1,650,109.

Process of Coking Pitch. Ray P. Perry, Upper Montclair, N. J., assignor to The Barrett Company.—1,650,127.

Apparatus for the Separation of Volatile Products from Solid Carbonaceous Material. Roy Eby Cotterman, Farmersville, Ohio.—1,650,191.

Process of Preparation from Starch, of Esters of the Higher Fatty Acids, Soluble in Hydrocarbons of the Aromatic Series. Paul Berthoin, Lyon, France, assignor to Société de Stearinerie et Savonnerie de Lyon, Lyon, France.—1,651,366.

Method of Bleaching Paper Pulp. Otto Kress, Appleton, Wis., assignor to American Lakes Paper Company, Chicago, Ill.—1,651,530.

Closed Wet-Starch System. Rush O. McCoy, Berwyn, Ill., assignor to International Patents Development Company, Wilmington, Del.—1,651,611.

Process of Making Esters. Hyym E. Buc, Roselle, N. J., assignor to Standard Development Company.—1,651,666.

Process for the Manufacture of Cellulose Acetate. Leonard Angelo Levy, Cricklewood, England, assignor to Apex (British)

Artificial Silk Ltd., Stratford, England.—1,652,024.

Manufacture of Hollow Artificial Textile Fibers. Joseph Edouard Gustave Lahousse, Ternay, France, assignor to Société pour la Fabrication de la Soie Rhodiaseta, Paris, France.—1,652,206.

Method of Making Dextrose. Charles Copland, Chicago, Ill., assignor to International Patents Development Company, Wilmington, Del.—1,652,393.

Manufacture of Cellulose Acetate. Herbert John Mallabar, Watford, England.—1,652,573.

Process for Reducing the Viscosity and Increasing the Solubility of Nitrocellulose. Stanley D. Shipley, Stamford, Conn., assignor to Atlas Powder Company, Wilmington, Del.—1,652,587.

Process for the Economical Reduction of Composite Sugar-Bearing Solutions. Henry Jermain Creighton, Swarthmore, Pa., assignor to Atlas Powder Company, Wilmington, Del.—1,653,004.

Interrelated Pulp-Refining and Viscose Process. George A. Richter, Berlin, N. H., assignor to Brown Company, Berlin, N. H.—1,653,124.

Process of Making Condensation Products. Howard W. Matheson, Montreal, Quebec, Canada, assignor to Canadian Electro Products Co. Limited.—1,653,302.

Manufacture of Chemical Wood Pulp. Armin Peetz, Alfelf, Germany.—1,653,730.

Process of Dyeing Artificial Silk. James Baddiley, Percy Chorley, and Carlton Butler, Manchester, England, assignors to British Dyestuffs Corporation Limited, Manchester, England.—1,653,757.

Removal of Tar Acids from Ammonia

Liquor and Other Liquors. Herbert William Robinson, Birmingham, and Deric William Parkes, West Bromwich, England.—1,653,783.

Gas-Purification Process. Frederick W. Sperr, Jr., and David L. Jacobson, Pittsburgh, Pa., assignors to The Koppers Company, Pittsburgh, Pa.—1,653,933.

Reagent for Treating Materials Containing Hydrocarbons and Process of Making the Same. Albert H. Ackerman, Chicago, Ill., assignor to Catalytic Chemical Company, Denver, Colo.—1,654,154.

Reagent for Treating Materials Containing Hydrocarbons and Process of Making the Same. Albert H. Ackerman, Chicago, Ill., assignor to Catalytic Chemical Company, Denver, Colo.—1,654,155.

INORGANIC PROCESSES

Method of and Apparatus for Making Nitric Acid. Arthur Hough, Summit, N. J., assignor to The Durrum Company, Inc., New York, N. Y.—1,649,901.

Hypochlorite Composition. Maurice C. Taylor, Niagara Falls, N. Y., assignor to The Mathieson Alkali Works, Inc.—1,650,054.

Process for the Production of Sodium Hydrosulphide and Valuable Byproducts. Earl Burnard Alvord, Cleveland, Ohio, assignor to The Grasselli Chemical Company, Cleveland, Ohio.—1,650,106.

Process for the Elimination of Phosphorus from Pig Iron. Rudolf Schenck, Munster, Germany, assignor to Vereinigte Stahlwerke Aktiengesellschaft, Dusseldorf, Germany.—1,650,157.

Process for Production of Hydrated Sodium Carbonate. Carl Sundstrom and George N. Terzlev, Syracuse, N. Y., assignors to The Solvay Process Company, Solvay, N. Y.—1,650,244.

Process and Apparatus for Producing a Gas of Uniform Sulphur-Dioxide Content. Henry Howard, Cleveland, Ohio, assignor to The Grasselli Chemical Company, Cleveland, Ohio.—1,650,358.

Process of Producing Ferrocyanides from Crude Calcium Cyanides. John M. Rugh, Elizabeth, N. J., assignor to American Cyanamid Company, New York, N. Y.—1,650,390.

Desiccation of Molten Metal Chlorides. Wilhelm Moschel and Philipp Siedler, Griesheim-on-the-Main, Germany, assignors to the Firm I. G. Farbenindustrie Aktiengesellschaft, Frankfurt-on-the-Main, Germany.—1,650,531.

Process for the Production of Magnesium from Magnesia Compounds. William Koehler, Cleveland, Ohio.—1,650,893.

Process for the Recovery of Sodium Compounds from Waste Sulphite Liquors. Charles H. Milligan, Wyoming, Ohio.—1,652,725.

Process of Synthesizing Oxides of Nitrogen. Camillo Joseph Goodwin, London, England, assignor to The Mathieson Alkali Works, New York, N. Y.—1,652,781.

Colloidal Calcium Carbonate and Method of Producing the Same. Taunaji Shiraiishi, Tatsuta Village, Miye, Japan.—1,654,099.

Process of Making Ammonium Chloride. Henry Howard, Cleveland, Ohio, assignor to The Grasselli Chemical Company, Cleveland, Ohio.—1,654,125.

Ammonia-Saturator Apparatus. Joseph Becker, Pittsburgh, Pa., assignor to The Koppers Company, Pittsburgh, Pa.—1,654,159.

Method for Preparation of Aliphatic Di- or Poly-Hydroxy-Arsonic Acids. Carl J. Oechlin, Ablon, France.—1,654,224.

CHEMICAL ENGINEERING EQUIPMENT AND PROCESSES

Process of Extracting Fats. Harold V. Atwell, Holliston, Mass.—1,648,102.

Method of Sulphur Mining. Benjamin Andrews, Houston, Tex.—1,648,210.

Dehydrator. Ellard L. Younger, Woodland, Calif., assignor to E. L. Younger & Sons, Woodland, Calif., a Partnership composed of E. L. Younger, Ellard L. Younger, and M. A. Younger.—1,648,468.

Shaking Screen. Charles Dahlberg, Anacosta, Mont.—1,648,543.

Separator. Laurence E. Brown, Rio de Janeiro, Brazil.—1,648,607.

Process of Extracting Fats. Harold V. Atwell, Whiting, Ind.—1,648,670.

Control System for Heat-Transfer Apparatus. Henry H. Buckman, Jacksonville, Fla.—1,648,672.

Gas-Density Meter. Jacob W. McNairy, Schenectady, N. Y., assignor, by mesne assignments, to Bailey Meter Company.—1,648,693.

Induction Furnace. James M. Weed, Scotia, N. Y.—1,648,707.

Apparatus for Measuring Ion Concentration. Ernst Mislowitz, Berlin, Germany.—1,648,739.

Pulverizer. Charles M. Stoner, Chambersburg, Pa., assignor to The Wolf Company, Chambersburg, Pa.—1,648,747.

Centrifugal Separating Apparatus. Robert Alexander Sturgeon, Brighouse, England.—1,648,790.

Vacuum Pump. Oskar Selts, Baden, Switzerland, assignor to the Firm Gleichrichter-Aktiengesellschaft, Glarus, Switzerland.—1,648,885.

Spray-Drying Apparatus. Walter H. Dickerson, East Orange, N. J., assignor to Industrial Waste Products Corporation, Dover, Del.—1,648,937.

Klin. Abel Hansen, Perth Amboy, N. J.—1,649,029.

Conveying Apparatus. Everton B. Powell, Newark, and Guerin Todd, Millburn, N. J., assignors to The Hanson & Van Winkle Company, Newark, N. J.—1,649,041.

Apparatus for Mixing and Proportioning Materials. Erie Palmer Halliburton, Los Angeles, Calif.—1,649,062.

Centrifugal Bowl Separator. Oswald C. Brewster, Casper, Wyo., assignor to The Sharples Specialty Company.—1,649,096.

Method and Mechanism for Centrifugally Separating Substances. Leo D. Jones, Philadelphia, Pa., assignor to The Sharples Specialty Company, Philadelphia, Pa.—1,649,117.

Method and Apparatus for Centrifugally Separating Substances. Leo D. Jones, Philadelphia, Pa., assignor to The Sharples Specialty Company.—1,649,118.

Heat Exchanger. Walter H. Kniskern, Syracuse, N. Y., assignor to Atmospheric Nitrogen Corporation, Syracuse, N. Y.—1,649,120.

Machine for the Production of Powdered Fuel. Charles E. Blyth, Dunchurch, England, assignor to Alfred Herbert Ltd., Coventry, England.—1,649,147.

Coal-Pulverizing Machine. Charles Edward Blyth, Stockton, near Rugby, England, assignor to Alfred Herbert Limited, Butts, Coventry, England.—1,649,148.

Fuller's Earth-Treating Process. Rudolph R. Rosenbaum, Chicago, Ill.—1,649,193.

Dust Separator. Alfred M. Goodloe, New York, N. Y., assignor to Midwest Steel & Supply Co., Inc., New York, N. Y.—1,649,220.

Liquid-Sampling Device. William W. Lewis, New Milford, Pa., assignor to Dairymen's League Co-operative Association, Inc., New York, N. Y.—1,649,241.

Rotary Pump. Amandus C. Roessler, Lakewood, Ohio, assignor to The Rotary Machine & Engineering Company, Cleveland, Ohio.—1,649,256.

Centrifugal Separating Apparatus. Frank Grimble, Matthew Nimmo Caird, and Edward Coombs, London, England.—1,649,346.

Pump. Arthur Hardt, Godesberg, Germany.—1,649,347.

Process of Treating Clays to Adapt Them for Decolorizing and Deodorizing Oils. John Seward Potter, Denver, Colo., assignor to The S. W. Shattuck Chemical Company, Denver, Colo.—1,649,366.

Methods of Mining Soluble Boron Compounds and The Like. Henry Blumenberg, Jr., Moapa, Nev.—1,649,385.

Filtering Material and Method of Making The Same. Henry Blumenberg, Jr., Moapa, Nev.—1,649,386.

Filter. Josef Hermann and Max Stauber, Cologne, Germany.—1,649,405.

Cooling Wheel. George E. Cox, Niagara Falls, N. Y., assignor to American Cyanamid Company, New York, N. Y.—1,649,511.

Hammer Crusher. George W. Borton, New Lisbon, and William A. Battey, Haverford, Pa., assignors to Pennsylvania Crusher Company, New York, N. Y.—1,649,565.

Method and Means for Removing Filter Cakes from Filter Mediums. Albert L. Genter and Jasper A. McCaskell, Salt Lake City, Utah, assignors to United Filters Corporation, New York, N. Y.—1,649,581.

Rotary Tubular Crystallizer Cooker. Fernand Lafeuille, Paris, France.—1,649,601.

Grinding Cement Material, Etc. Eduard Zeuthen Dalgaard, Copenhagen, Denmark, assignor to F. L. Smith & Co., New York, N. Y.—1,649,313.

Filter-Press Cloth. Frank R. Furbish, New York, N. Y., assignor to The Filter Sack Manufacturing Co., Cleveland, Ohio.—1,649,822.

Rotary Drying Apparatus. Horace Arthur Marston, Sutton, England.—1,649,839.

Vibrating Screen. Herbert S. Woodward, Carbondale, Pa.—1,649,883.

Mixing and Disintegrating Apparatus. Frank M. Wichman and Alfred P. Hartlapp, Salt Lake City, Utah, assignors to United States Smelting, Refining & Mining Company, Portland, Me.—1,649,939.

Double-Gate Balanced Valve. Charles A. Ernst, Rainier, Wash.—1,649,953.

Colloid Mill. Louis A. Molin, New York, N. Y.—1,650,088.

Electrical Precipitator. Walter A. Schmidt, Los Angeles, Calif., assignor to International Precipitation Company, Los Angeles, Calif.—1,650,097.

Dewatering Apparatus for Pulp. Julius Stephansen, Drammen, Norway.—1,650,100.

Apparatus for Electrical Separation of Suspended Particles from Gases. Evald Anderson, Alhambra, Calif., assignor to International Precipitation Company, Los Angeles, Calif.—1,650,105.

Vacuum Pan. August Gräntzdörffer, Magdeburg, Germany.—1,650,122.

Coke and Process of Producing the Same. Thomas H. Hall, Nyack, N. Y., assignor to The Barrett Company.—1,650,126.

Method of Degassing Water. David S. Jacobus, Jersey City, N. J., assignor to The Babcock & Wilcox Company, Bayonne, N. J.—1,650,129.

Filter Press. Max Korff, New York, N. Y., assignor to J. P. Bemberg Aktiengesellschaft, Barmen-Rittershausen, Germany.—1,650,138.

Heat-Interchange Device. Hans Kühni, Rumlach, Switzerland, assignor, by mesne assignments, to Air Reduction Company, Inc.—1,650,140.

Process and Device for Fume Control. Robert S. Perry, New York, N. Y.—1,650,152.

Gas Producer. William Climie, Mossend, Lanarkshire, Scotland.—1,650,187.

Gas Producer. William Climie, Toronto, Ontario, Canada.—1,650,188.

Hydraulic Classifier and Separating Process. Frederick W. Schmidt and William M. Green, Morristown, N. J.—1,650,239.

Heat-Exchanging Mechanism. Loyd R. Stowe, St. Louis, Mo.—1,650,242.

Wood Impregnation. Arthur M. Howald, Pittsburgh, Pa., assignor to The Grasselli Chemical Company, Cleveland, Ohio.—1,650,274.

Dust Collector. Hugh Miscampbell, Duluth, Minn.—1,650,292.

Manufacture of Condensed Liquids. John Milton McClatchie, New York, N. Y., assignor to The Borden Company, New York, N. Y.—1,650,373.

Continuous Filter. Arthur C. Daman, Denver, Colo.—1,650,434.

Separator. Augustus A. Bennett and Ernest H. McWhorter, Coffeyville, Kans.—1,650,484.

Compound Mill. Paul Gebels, Dessau, Germany, assignor to the Firm G. Poly-sius, Dessau, Germany, a Partnership.—1,650,508.

Apparatus for Aerating Liquids. William Hucks, Camden Town, London, England, assignor of one-half to Sodastream Limited, London, England.—1,650,516.

Vacuum Pump. Howell V. Ringgenberg, Rochester, Minn., assignor of one-half to Roy E. Oesterreich, Rochester, Minn.—1,650,539.

Process and Apparatus for Separating Liquids from Solids. Hans C. Behr, Scarsdale, N. Y.—1,650,685.

Air Classifier. Albert H. Stebbins, Los Angeles, Calif.—1,650,727.

Thickener. Harrison S. Coe, Palo Alto, Calif.—1,650,820.

Refrigeration. Nils Persson, Stockholm, Sweden, assignor to Electrolux Servel Corporation, New York, N. Y.—1,651,410.

Apparatus for Recovering the Volatile Products from Carbonaceous Material. Milon J. Trumble, Alhambra, Calif.—1,651,647.

Leaching Apparatus. Henry Y. Eagle, Brooklyn, N. Y., assignor of one-half to Archer E. Wheeler, New York, N. Y.—1,651,680.

Method and Apparatus for Treating Fiber. August F. Richter, Watertown, and Frank A. Augsburg, Ogdensburg, N. Y., assignors to Stebbins Engineering and Manufacturing Company, Watertown, N. Y.—1,653,416.

Process and Apparatus for Concentrating Fluids. Willis A. Gibbons and Morris G. Shepard, New York, N. Y., assignors to General Rubber Company, New York, N. Y.—1,651,764.

Process of Distilling Materials. Hiram B. Cannon, Metuchen, N. J.—1,651,994.

Method of and Apparatus for Treating One Fluid by Another. Samuel J. Dickey, Los Angeles, Calif., assignor to General Petroleum Corporation of California.—1,652,399.

Waste-Heat Boiler System. Heinrich Koppers, Essen-Ruhr, Germany, assignor to The Koppers Development Corporation, Pittsburgh, Pa.—1,653,635.

Crystallizer. Fernand Lafeuille, Paris, France.—1,653,712.

Method of Decolorizing Oils Under Pressure. Paul W. Prutzman, Los Angeles, Calif., assignor, by mesne assignments, to Contact Filtration Company, San Francisco, Calif.—1,653,735.

Apparatus for the Treatment of Gases with Liquids. Matthew D. Mann, Jr., Roselle, N. J., assignor to Seth B. Hunt, trustee, Mount Kisco, N. Y.—1,654,181.

Deaerator. Russell C. Jones, Bronxville, N. Y., assignor to the Griscom-Russell Company, New York, N. Y.—1,654,260.